Chapter 3

EXPERIMENTAL RESULTS

Summary statistics and preliminary conclusions for all experiments are presented in this chapter. Subsequent chapters present further statistical analysis, discussion and modeling pertaining to individual experiments. Unless otherwise noted statistics were calculated using the SAS statistics package on an IBM PC compatible desk top computer.

Experiment 1

The beam balance used to weigh microlysimeters (ML's) introduced considerable error as evidenced by the negative daily and cumulative weight changes shown in Table 3-1 and Figure 3-1. In the laboratory the balance weighed repeatedly to within 2 to 3 gm (0.4 to 0.6 mm depth of water). However, in the field with loads up to 3,000 g the balance gave a precision of only 7 to 10 gm or worse (1.3 to 1.9 mm or more, depth of water). These errors occurred despite an enclosure to shield the balance from the wind, and careful leveling before use. Additional experimental error was introduced on the first day after irrigation by the fact that 6 hours passed between the time that the first ML was weighed at 9:15 AM and

Table 3-1.

Daily microlysimeter water content changes in mm, Experiment 1.

Microlysimeters are listed following the order in which they were weighed on the first day. ML code number 25 was weighed at 9:15 AM and ML code number 113 was weighed at 3:15 PM on the first day after irrigation.

Wall Type	Length (cm)	Code No.	Day after irrigation 1	2	3	4	5	6	7	8	9	Total loss	Loss after First day
P	20	25	4.98	3.26	1.92	-0.96	1.34	2.68	1.15	0.77	-0.19	14.95	9.97
S	20	26	5.92	1.39	1.22	1.05	1.05	1.39	1.05	-0.17	0.87	13.76	7.84
S	30	27	6.97	0.87	1.39	0.17	1.05	3.31	-0.17	0.87	0.00	14.46	7.49
P	30	28	5.75	0.96	1.53	0.77	2.68	-0.77	1.73	0.77	0.77	14.19	8.44
S	10	29	4.01	1.57	1.22	0.70	0.70	1.74	0.52	0.70	0.70	11.84	7.83
P	10	210	5.18	1.73	1.15	0.77	1.34	0.38	0.77	0.96	0.58	12.84	7.66
S	20	211	4.53	2.09	1.05	1.05	1.39	0.52	0.52	1.39	-0.17	12.37	7.84
P	20	212	3.83	3.64	-0.58	1.34	1.53	0.96	0.00	0.77	0.38	11.88	8.05
S	10	15	3.14	1.74	1.57	1.22	0.70	1.05	0.70	0.87	0.35	11.32	8.18
P	20	16	2.49	2.30	1.34	0.96	1.15	0.38	0.77	0.96	0.38	10.73	8.24
S	30	17	3.83	4.01	0.00	1.39	0.52	2.09	0.52	0.87	-0.17	13.06	9.23
P	30	18	1.73	2.49	0.38	2.11	0.19	2.49	0.38	1.15	-0.19	10.73	9.00
S	10	19	3.48	1.05	1.74	1.22	1.22	0.52	1.05	1.22	0.17	11.67	8.19
P	10	110	1.34	1.53	1.34	0.77	1.15	1.15	0.58	0.96	0.77	9.58	8.24
S	20	111	1.92	1.57	2.09	1.05	0.17	1.22	1.22	0.87	-0.52	9.58	7.66
P	20	112	1.53	0.96	1.15	1.15	1.53	0.77	0.77	1.73	0.00	9.58	8.05
P	10	113	0.96	1.73	1.34	0.77	1.34	0.58	0.96	1.15	0.19	9.01	8.05

			Treatment Number	Time of 1st day weighing
P	20	25	4	9.25
S	20	26	3	9.58
S	30	27	5	9.85
P	30	28	6	10.12
S	10	29	1	10.37
P	10	210	2	10.58
S	20	211	3	10.80
P	20	212	4	11.03
S	10	15	1	13.45
P	20	16	4	13.72
S	30	17	5	14.08
P	30	18	6	14.30
S	10	19	1	14.48
P	10	110	2	14.65
S	20	111	3	14.85
P	20	112	4	15.05
P	10	113	2	15.25

Wall Type:
- P = PVC plastic
- S = steel

Treatments:
- 1 = steel, 10 cm length
- 2 = plastic, 10 cm length
- 3 = steel, 20 cm length
- 4 = plastic, 20 cm length
- 5 = steel, 30 cm length
- 6 = plastic, 30 cm length

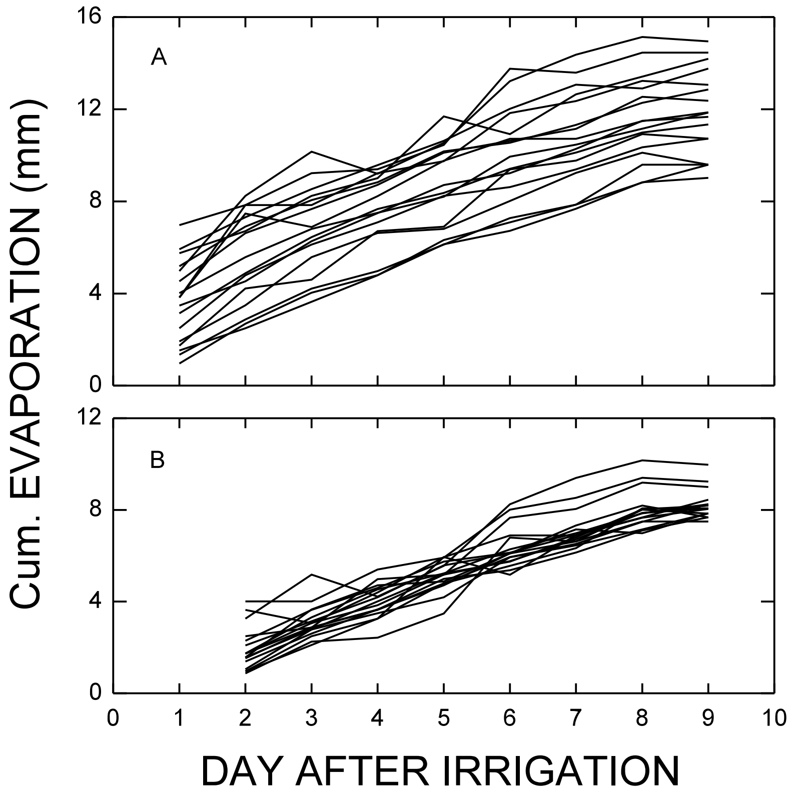

Figure 3-1. Cumulative microlysimeter evaporation, mm, Experiment 1. A. Cumulative evaporation from first day after irrigation. B. Cumulative evaporation from second day after irrigation.

the last at 3:15 PM (Table 3-1). The evaporation that occurred during that period may have amounted to as much as 4 to 6 mm, skewing the results from the first day as well as the totals of evaporation.

As a check on the evaporation rates measured by microlysimetery, the potential evapotranspiration, ET_p, was calculated on a half-hourly basis using the Penman method as modified by Doorenbos and Pruitt (1984) and Pruitt and

Doorenbos (1977). See Appendix A for details of calculations and for equations relating net radiation to solar radiation. On the first day after irrigation the maximum evaporation measured by microlysimetery was, at 7.0 mm, only slightly larger than the 6.8 mm ET_p (Figure 3-2). The microlysimeter that generated the 7.0 mm figure was weighed before 10 AM on the first day. All other values of evaporation measured by ML's were well below ET_p. Generally ET_p increased with time due to higher net radiation. Although skies were never completely overcast, there was a general clearing trend with

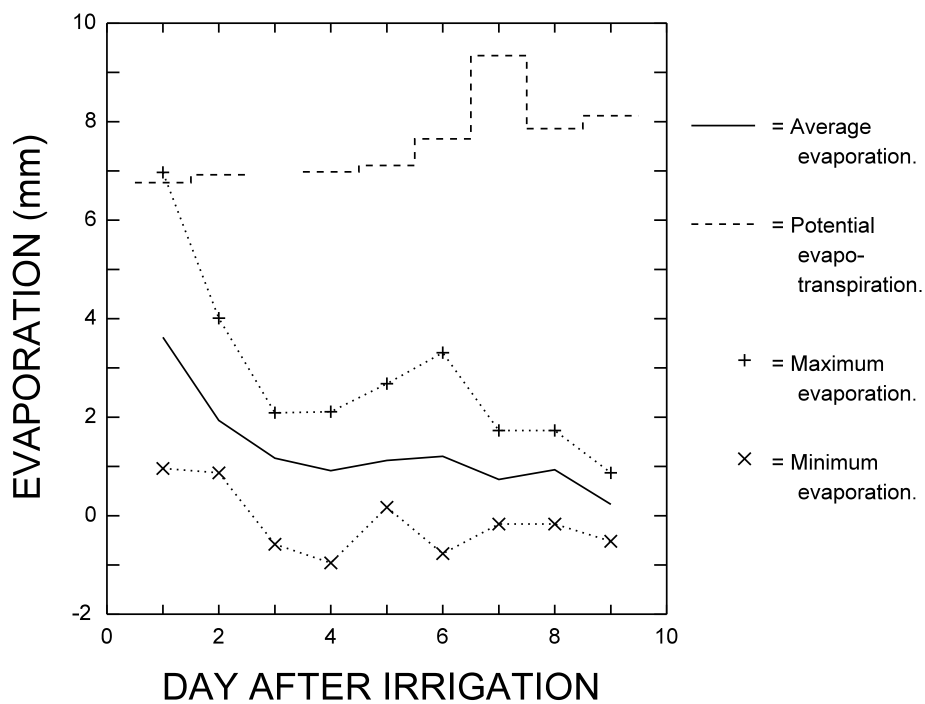

Figure 3-2. Average, minimum and maximum measured evaporation compared to potential evapotranspiration, 17 ML's.

cloudier conditions at the beginning of the experiment. The peak ET_p of 9.3 mm occurring on day 7 was caused by windy conditions (average daytime wind of 3.1 m/s).

Water contents measured on the first day after irrigation ranged from 0.22 to 0.29 m^3/m^3 (Table 3-2). The wide range of initial water content was partially due to drainage and evaporation that took place before the last ML was weighed. Each of the three treatments of steel ML's (10, 20 and 30 cm lengths) was initially more moist, on average, than the equivalent treatment for plastic ML's. Since the experiment was well blocked and since steel and plastic ML's were alternated in the order of weighing, the different water contents were probably not due to placement but rather to greater evaporation from plastic as compared to steel ML's before the first weighing.

On the last day also, steel ML's had higher water contents than did plastic ones, on average. More importantly, the average decrease in water content from day 93 to day 101 was larger for each treatment of plastic ML's than the average decrease for the equivalent treatment of steel ML's. (The first day after irrigation was omitted from this calculation due to the bias introduced by late weighings on day 92.) The largest difference, between 20 cm steel and plastic ML's, was

Table 3-2.

Daily water contents (m^3/m^3), and cumulative change in water content and evaporation from day 93 to day 101, Experiment 1.

Treatment	Code	Day 92	93	94	95	96	97	98	99	100	101	Change in Θ_v 93 to 101.	Cum. Evap. (mm)
Steel, 10 cm.	15	0.255	0.226	0.211	0.197	0.186	0.179	0.170	0.164	0.156	0.153	0.0738	
	19	0.272	0.240	0.231	0.215	0.204	0.193	0.188	0.179	0.168	0.166	0.0738	
	29	0.264	0.228	0.214	0.203	0.197	0.191	0.175	0.170	0.164	0.158	0.0706	
	Average:	0.263	0.232	0.218	0.205	0.195	0.188	0.178	0.171	0.163	0.159	0.0727	8.1
Plastic, 10 cm.	113	0.221	0.212	0.196	0.183	0.176	0.163	0.157	0.148	0.137	0.135	0.0767	
	210	0.265	0.215	0.199	0.188	0.181	0.168	0.164	0.157	0.148	0.142	0.0730	
	Average:	0.243	0.214	0.197	0.185	0.178	0.165	0.161	0.152	0.142	0.139	0.0748	7.9
Steel, 20 cm.	26	0.290	0.262	0.255	0.249	0.244	0.239	0.233	0.228	0.229	0.225	0.0372	
	111	0.255	0.246	0.239	0.229	0.224	0.223	0.217	0.211	0.207	0.210	0.0363	
	211	0.275	0.253	0.243	0.238	0.233	0.227	0.224	0.222	0.215	0.216	0.0372	
	Average:	0.273	0.254	0.246	0.239	0.234	0.230	0.225	0.220	0.217	0.217	0.0369	7.8
Plastic, 20 cm.	16	0.255	0.243	0.231	0.225	0.220	0.214	0.213	0.209	0.204	0.202	0.0402	
	25	0.271	0.246	0.230	0.221	0.226	0.219	0.206	0.201	0.197	0.198	0.0486	
	112	0.249	0.242	0.237	0.232	0.226	0.218	0.215	0.211	0.203	0.203	0.0393	
	212	0.269	0.251	0.233	0.236	0.229	0.222	0.217	0.217	0.213	0.211	0.0393	
	Average:	0.261	0.245	0.233	0.228	0.225	0.218	0.213	0.209	0.204	0.204	0.0419	8.6
Steel, 30 cm.	17	0.294	0.282	0.269	0.269	0.264	0.263	0.256	0.254	0.252	0.252	0.0299	
	27	0.271	0.248	0.246	0.241	0.241	0.237	0.227	0.227	0.224	0.224	0.0241	
	Average:	0.283	0.265	0.257	0.255	0.253	0.250	0.241	0.241	0.238	0.238	0.0269	8.4
Plastic, 30 cm.	18	0.289	0.284	0.275	0.274	0.267	0.267	0.258	0.257	0.253	0.254	0.0295	
	28	0.262	0.243	0.240	0.235	0.232	0.224	0.226	0.220	0.218	0.215	0.0277	
	Average:	0.276	0.263	0.258	0.254	0.250	0.245	0.242	0.239	0.236	0.235	0.0286	8.7

a water content change of 0.037 m^3/m^3 for steel ML's vs. a change of 0.042 m^3/m^3 for plastic. Thus 20 cm long plastic ML's lost 14% more water than did steel ML's of the same length. Statistical analysis of these results is presented in Chapter 4 along with heat flux calculations that show that the increased heat flux in steel vs. plastic ML's may well account for the decreased evaporation from steel ML's.

Cumulative evaporation over the 9 day period was also different, both for plastic compared to steel ML's which exhibited less evaporation, and for shorter lengths compared to longer lengths. At the 20 and 30 cm lengths, plastic ML's clearly showed more evaporation than did steel. The increase in cumulative evaporation with length seems obvious for plastic ML's, but is not clear for steel. If heat conduction by steel ML walls lowered the energy available for evaporation then the effect of length would be expected to be lessened.

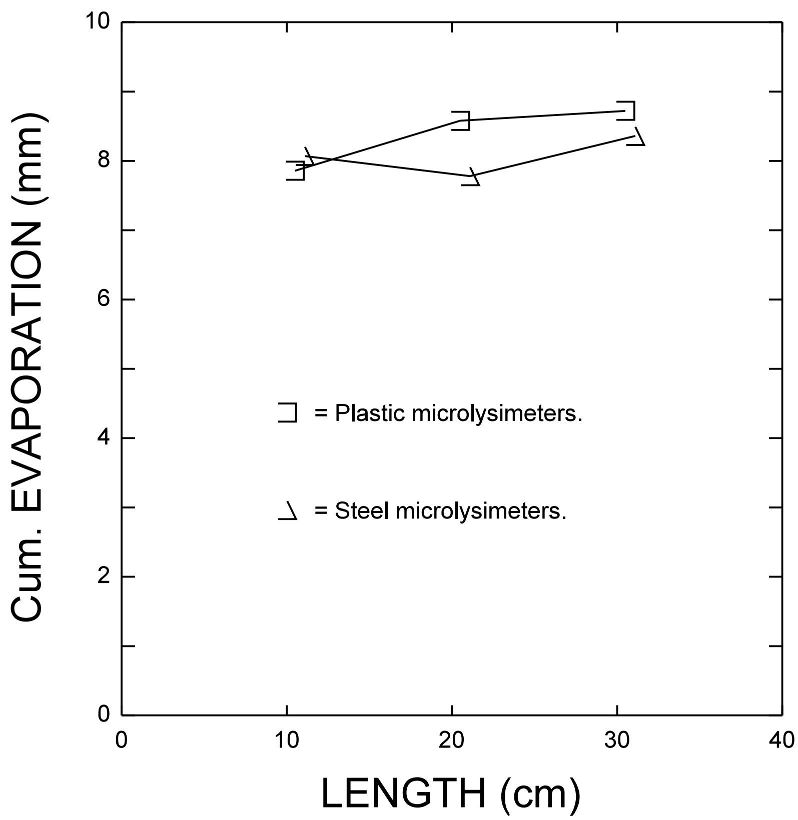

Figure 3-3. Cumulative evaporation from steel and from plastic microlysimeters of three lengths.

Average daily wind speeds varied from 1.60 m/s on day 92 to 3.29 m/s on day 98. Wind speeds averaged over 1/2 hour were even more variable, often changing by almost an order of magnitude over 1 day (Figure 3-4).

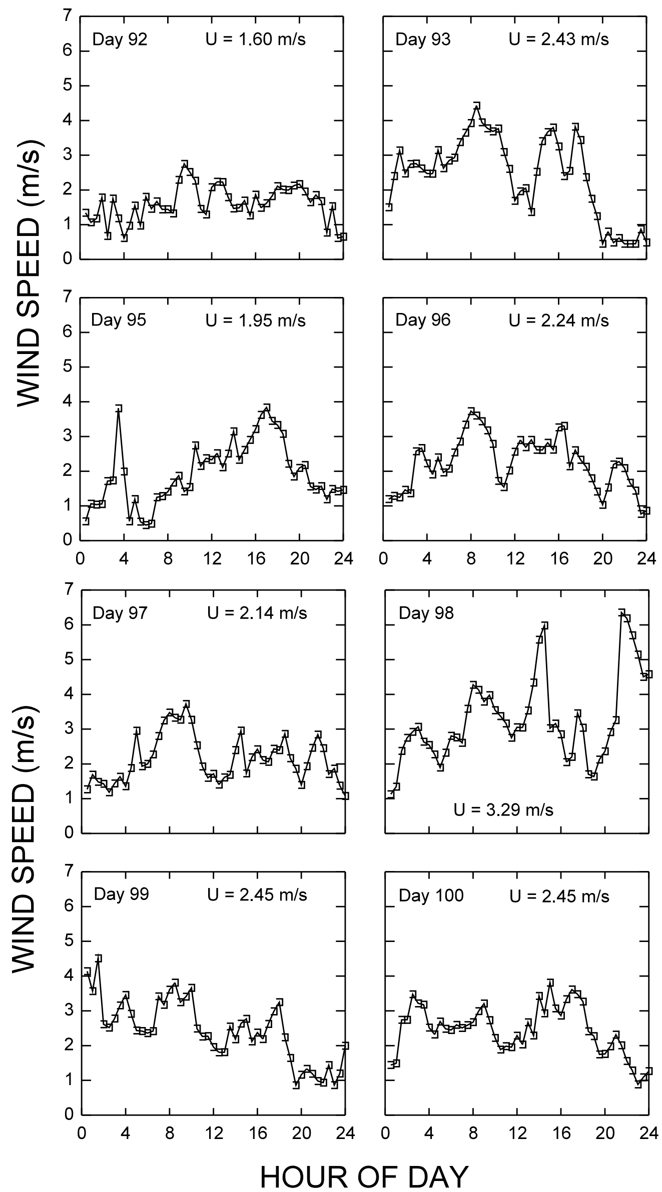

Figure 3-4. Half-hourly average wind speeds, Experiment 1, illustrating non-constant behavior.

In order to examine the degree of sensible heat flux at night, surface temperatures of some 30 cm long ML's, field soil, and the reference dry soil were plotted with air temperature (Figures 3-5 to 3-8). Generally, the differences between soil and air temperatures were much greater during the day than at nighttime. For the nights of days 95-96, 96-97 and 99-100, the difference between air and drying soil temperature was nil yet the difference between dry and drying soil temperatures was considerable, especially for the nights of days 95-96 and 96-97 when the largest negative temperature depressions were recorded (reference dry soil about 4 °C less than drying soil in steel ML's). The relatively small differences among soil temperatures and between soil and air temperatures suggest that sensible heat flux is small at night.

Other features of Figures 3-5 to 3-8 are interesting. At night, when longwave radiation flux should dominate the energy balance, the 2 treatments of plastic ML's (open bottoms or bottoms closed with 6 mm thick PVC plastic) showed nearly identical temperatures which closely followed the temperature of the field soil. The 2 treatments of steel ML's also showed nearly equal temperatures and were consistently warmer than plastic ML's and the field soil. Nighttime surface temperatures of all ML's were always warmer than that of the

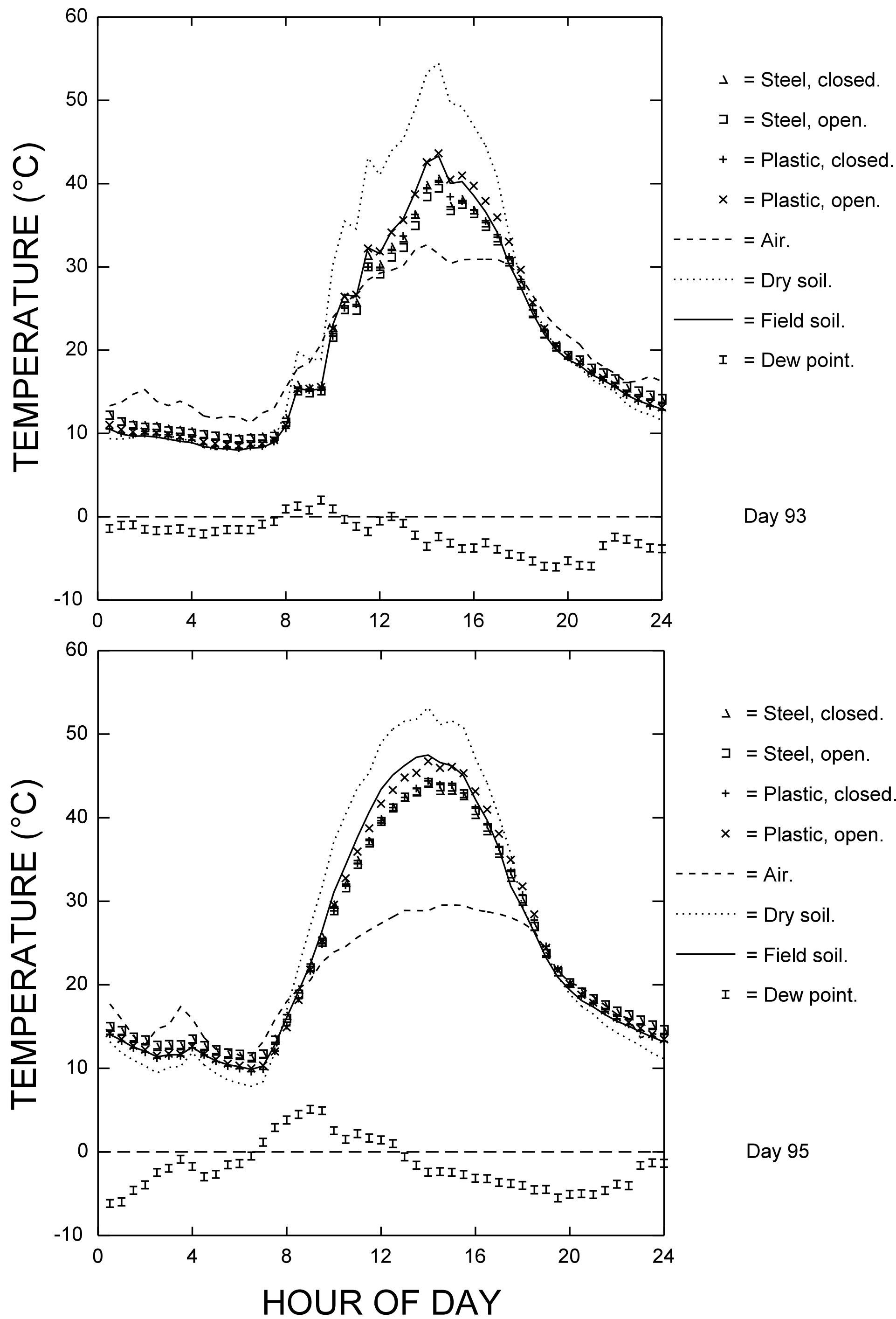

Figure 3-5. Surface soil and microlysimeter temperatures, and air and dew point temperatures, Experiment 1, days 93 and 95.

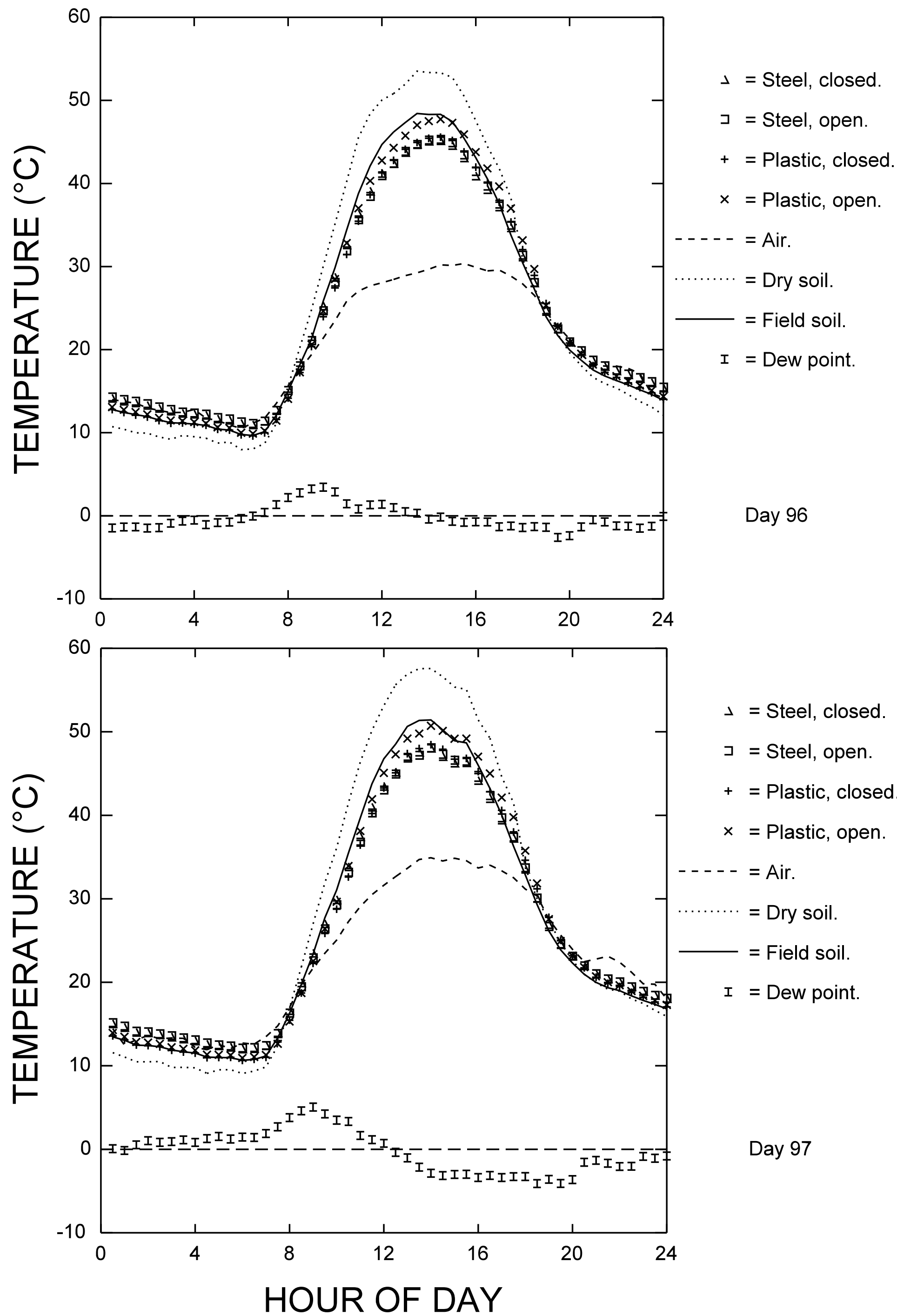

Figure 3-6. Surface soil and microlysimeter temperatures, and air and dew point temperatures, Experiment 1, days 96 and 97.

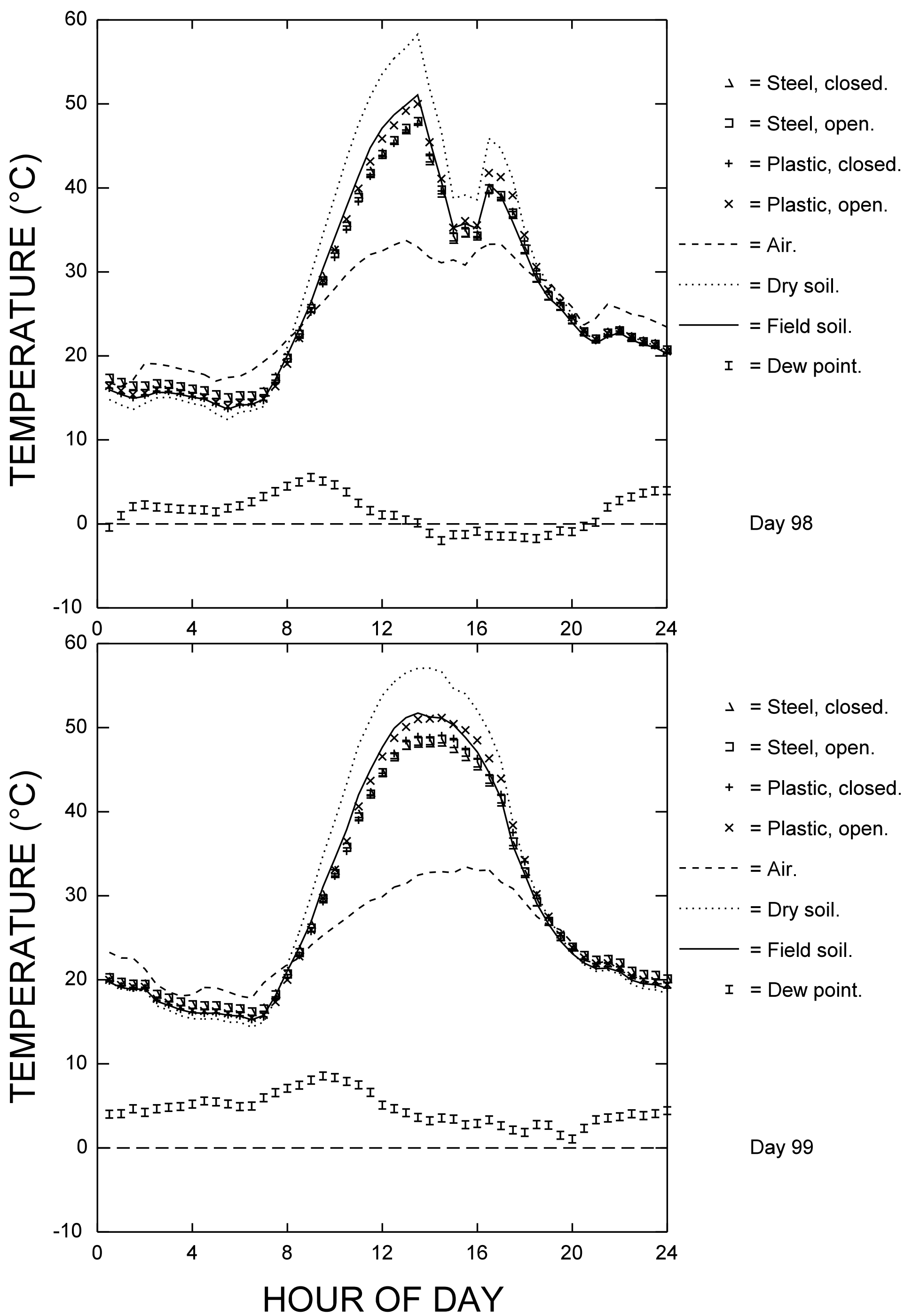

Figure 3-7. Surface soil and microlysimeter temperatures, and air and dew point temperatures, Experiment 1, days 98 and 99.

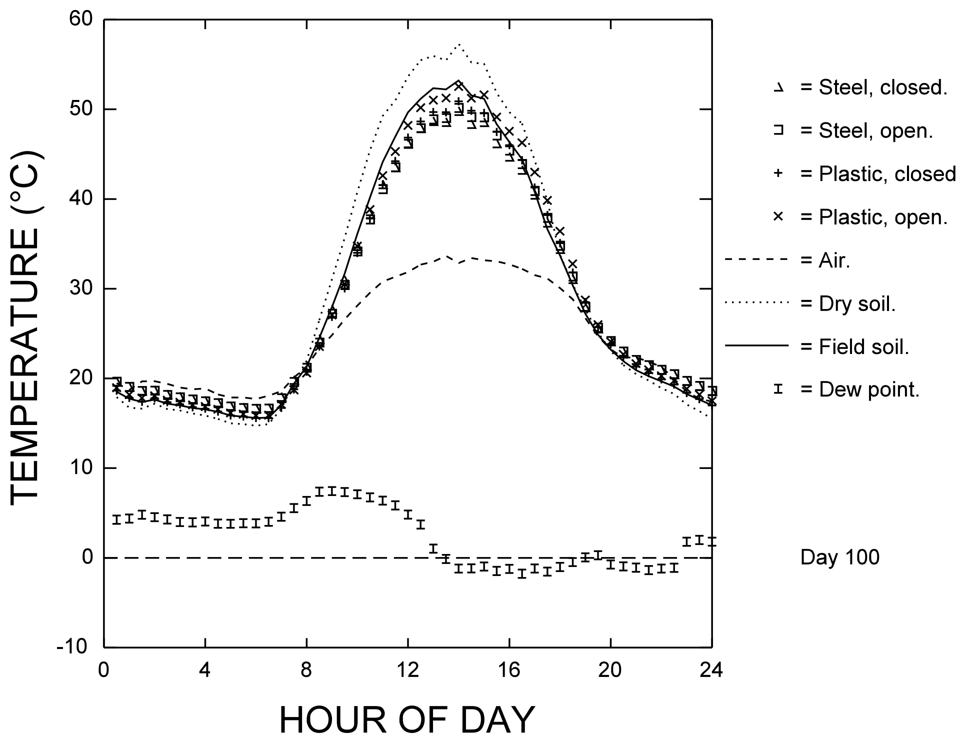

Figure 3-8. Surface soil and microlysimeter temperatures, and air and dew point temperatures, Experiment 1, day 100.

reference dry soil showing the importance of higher soil heat flux in the moister soils. Generally, the nighttime differences in temperature, between dry and drying soils, were largest early on and diminished as the experiment progressed. Nighttime air temperatures were consistently warmer than those of plastic ML's but sometimes equaled or were lower (rarely) than those of steel ML's. The dew point was never reached at any of the soil surfaces.

During the day, the temperatures, of both treatments of steel ML's and of the plastic ML's with closed bottoms, were nearly equal. Temperatures of plastic ML's with open bottoms were consistently warmer and, except for some lag, were close to those of the field soil. Temperatures of all ML's and of the field soil were consistently lower than dry soil temperatures. During the day, ML and field soil temperatures were higher than air temperatures except for a variable period of from 1 to 3 hours after sunrise. As the soils dried this period became shorter. Thus, the atmosphere over both microlysimeters and reference dry soil was unstable during most daytime hours and was stable or neutral at night.

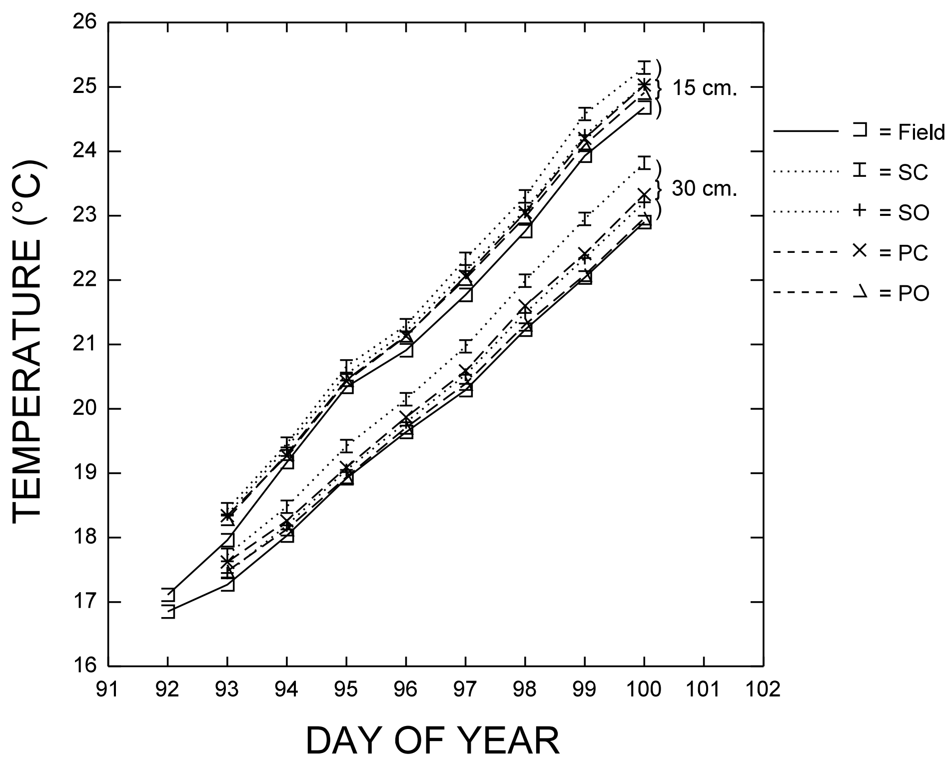

Figure 3-9. Average soil temperatures at 15 cm and 30 cm for field soil and microlysimeters. S = steel, P = plastic, O = open bottom, C = closed bottom.

Soil temperatures at 15 and 30 cm showed a strong linear warming trend of 6 to 7 °C over 7 days for all ML types and for the field soil (Figure 3-9). Examination of the diurnal soil temperature regime at 3 depths (surface, 15 cm and 30 cm) showed marked differences between steel and plastic ML's (Figures 3-5 through 3-8, 3-10, 3-11). Differences were also evident between ML's which were closed at their bottoms with plastic disks and those that were left in direct contact with the underlying soil (Figure 3-10). There were important differences between steel and plastic ML's in the timing of subsurface temperature maxima and minima while at the surface

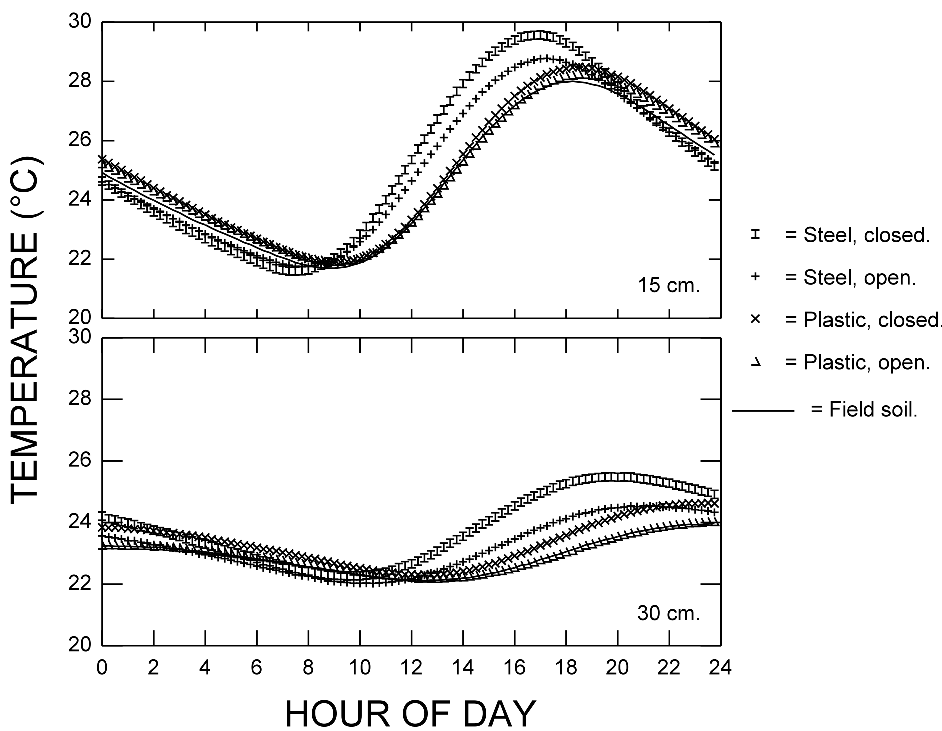

Figure 3-10. Average subsurface temperatures for field soil and microlysimeter treatments. Ninth day after irrigation.

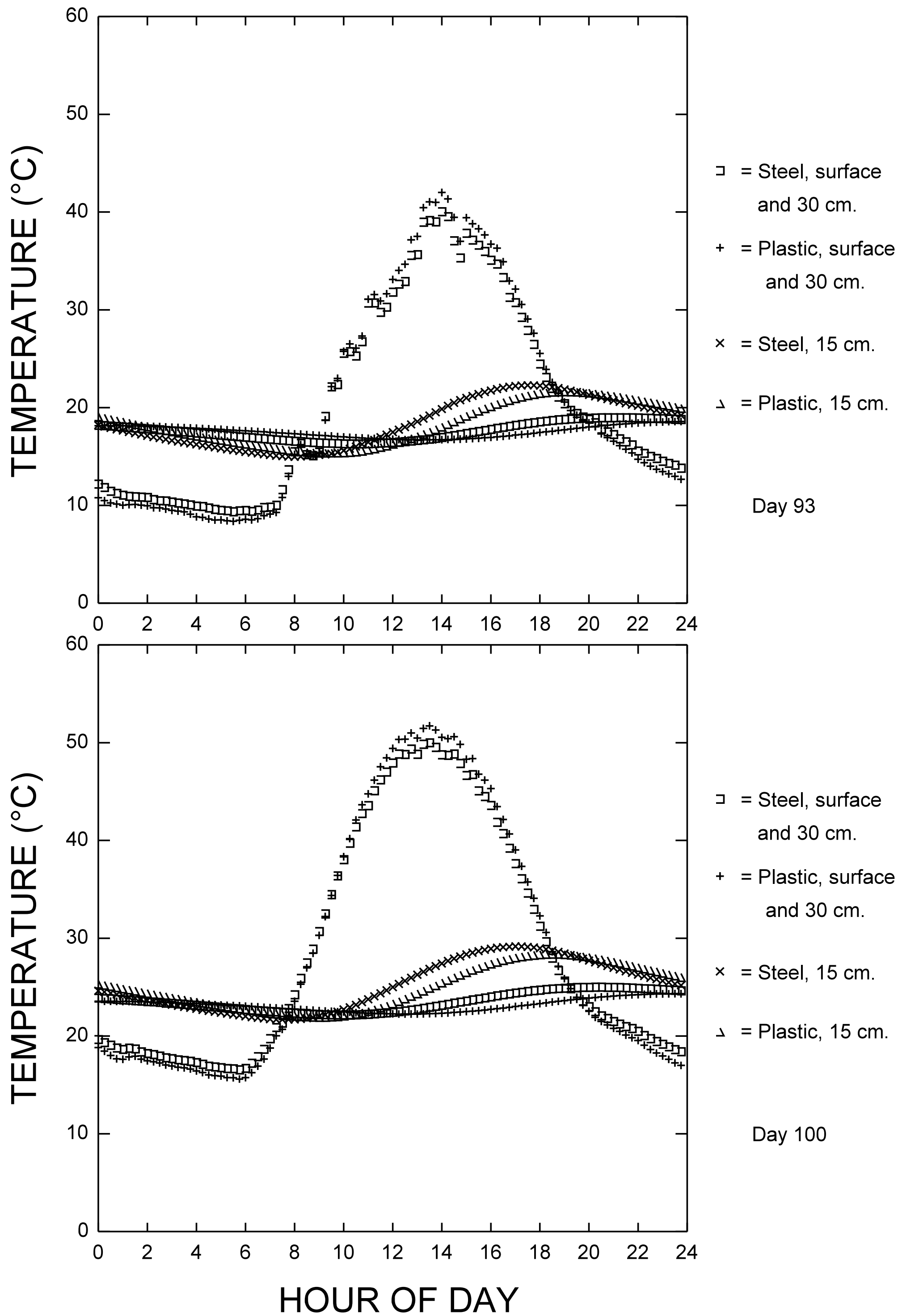

Figure 3-11. Soil temperature regime in microlysimeters averaged by wall material treatment, second and ninth days after irrigation.

there was no such difference (Table 3-3). At 15 cm depth the diurnal wave of temperature for steel ML's peaked between 1.25 and 1.4 hours in advance of that for plastic ML's. At 30 cm depth the difference increased to between 2.8 and 3.0 hours.

Table 3-3.

Average phase shift in hours between the time of temperature maxima and minima in steel microlysimeters and that in plastic microlysimeters, at 15 and 30 cm depths.

	Daily maxima		Daily minima	
	15 cm	30 cm	15 cm	30 cm
Phase shift in temperature maxima and minima, hours.	1.41	3.03	1.25	2.81

Surface soil in plastic ML's reached higher daytime maximum temperatures and lower nighttime minimum temperatures than did surface soil in steel ML's. This was true for all days (Figure 3-12). The subsurface soil temperature regime was reversed with steel ML's showing higher temperature maxima and lower minima than did plastic ML's. Clearly steel ML's conducted heat from and to the soil surface much more quickly than did plastic.

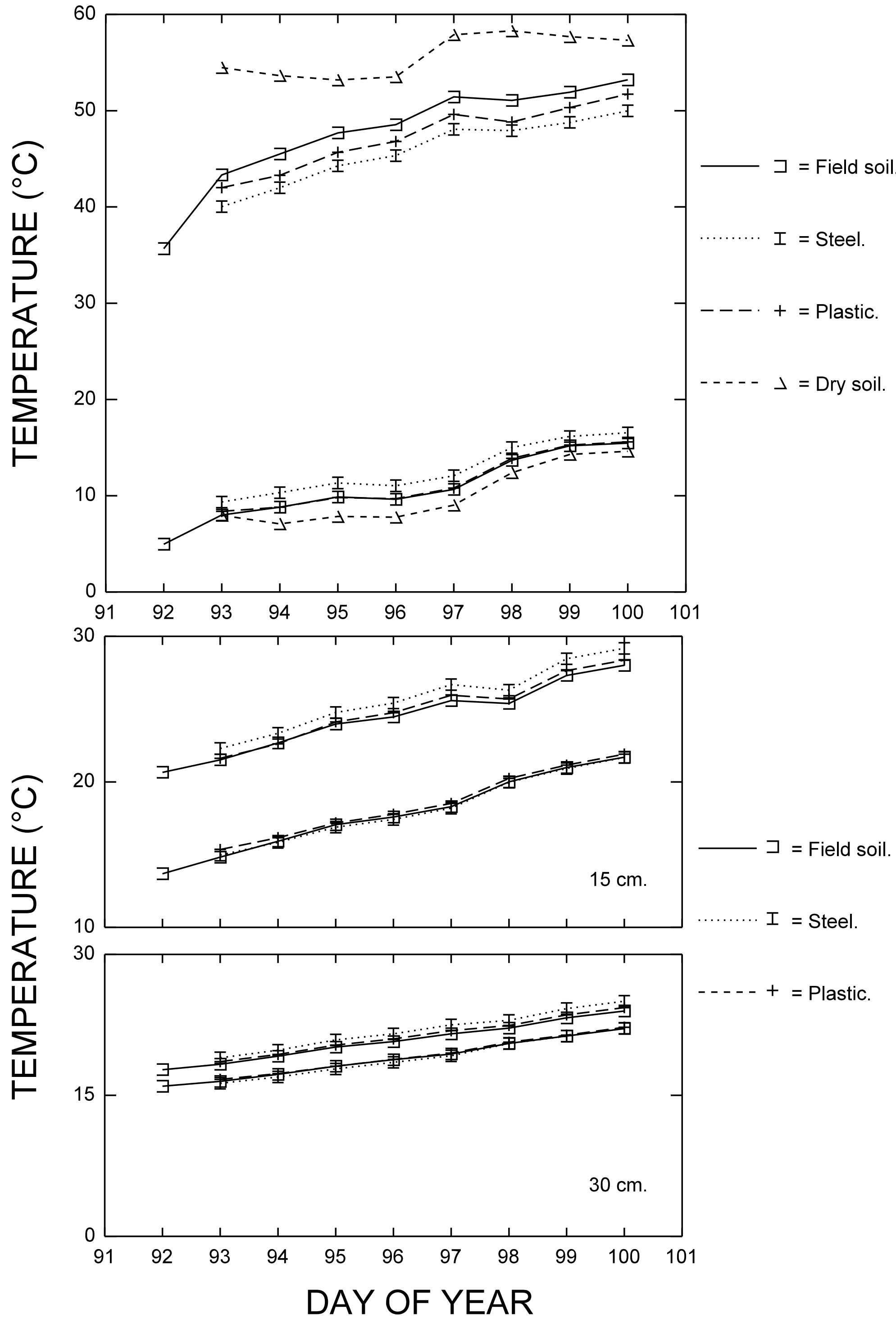

Figure 3-12. Minimum and maximum field soil and microlysimeter temperatures at the surface (top), 15 cm (middle) and 30 cm (bottom).

Table 3-4.

Average differences between plastic and steel microlysimeters in daily soil temperature maxima and minima at 3 depths. Differences were calculated by subtracting temperature in steel ML from temperature in plastic ML.

DAILY MAXIMA	Surface	15 cm	30 cm
Average difference between temperature maxima, degrees C.	1.486	-0.707	-0.540

DAILY MINIMA	Surface	15 cm	30 cm
Average difference between temperature minima, degrees C.	-1.201	0.297	0.249

Experiment 2

The second experiment consisted of three irrigations and associated measurements of change in soil moisture and distribution of irrigation water as measured by the neutron probe and catch cans at 57 locations. The depth of water stored in the profile at each location was calculated by multiplying the depth of each layer by its volumetric water content and summing these depths of water (Table 3-5). Each layer was assumed to be centered on the depth of the neutron probe reading with the layer's upper and lower boundaries determined as the midpoints between probe reading depths. For the topmost layer the soil surface formed the upper boundary while for the bottom layer the lower boundary was set at 120 cm.

The change in profile water contents was generally less than 2 mm daily indicating the slow rate of drainage from the profile. Neutron scattering measurements took several hours to complete, often ending after noon on a given day. Thus the changes in profile water content discussed here are indicative only of general day to day trends. Specifically, the change in storage due to irrigation was not measured precisely due to the time lag between neutron scattering on the day before irrigation and on the day after.

Table 3-5.

Simple statistics for daily profile water content (cm), Irrigations 1, 2 and 3, Experiment 2.

Day	N	Mean	Std Dev	Median	Minimum	Maximum
77	57	23.4	5.39	24.6	12.5	35.2
Irrigation 1						
80	57	27.3	5.84	28.2	14.1	42.2
81	56	27.0	5.82	27.9	14.0	41.4
82	57	26.8	5.78	27.9	13.9	41.2
83	57	26.7	5.72	27.8	13.9	40.7
85	57	26.6	5.64	28.0	13.7	38.4
90	57	26.4	5.51	27.9	13.5	37.9
Irrigation 2						
92	57	27.3	5.61	28.6	13.8	39.1
93	55	27.1	5.83	28.3	13.7	38.5
94	57	26.8	5.64	28.5	13.6	38.5
95	57	26.8	5.67	28.3	13.5	38.7
96	57	26.7	5.62	28.3	13.6	38.3
98	56	26.6	5.65	28.3	13.5	38.1
100	55	26.4	5.50	28.2	13.4	37.7
Irrigation 3						
102	55	27.1	5.60	28.1	13.5	38.6
103	53	27.0	5.30	28.4	15.2	38.2
105	52	26.4	5.67	28.3	13.4	37.9

Irrigation and Change in Storage.

At 3.85 cm, the change in storage due to the first irrigation was only slightly lower than the 4.16 cm which was the average depth of water in the catch cans (Table 3-6). Change in storage was much more variable than irrigation catch can depth (Figure 3-13). Prior to this irrigation the field was at its driest. The presence of soil cracks of up to 2 cm width may have contributed to the variability of change in storage. These cracks were not present prior to the second and third irrigations. Ponding and flooding occurred during all irrigations.

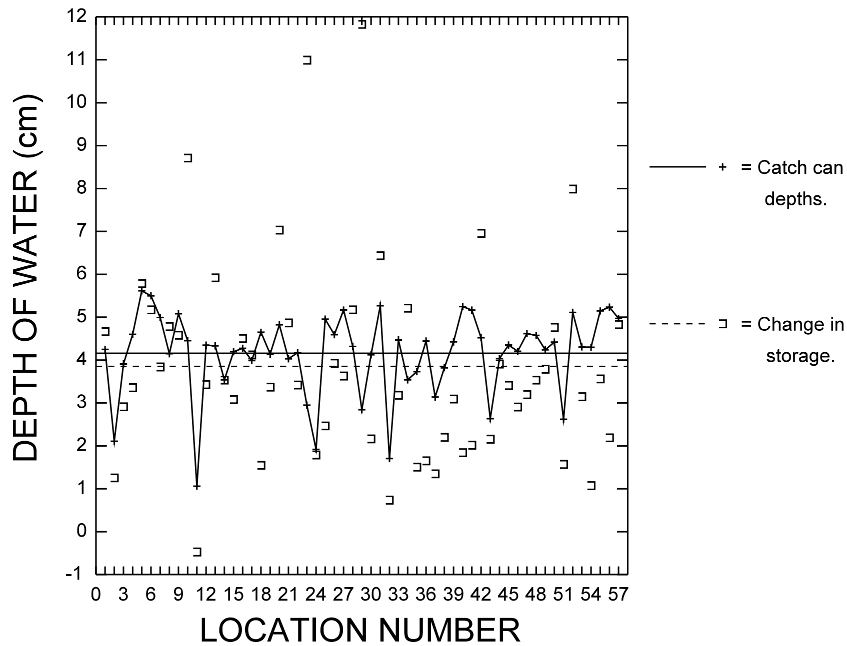

Figure 3-13. Catch can depths and change in storage due to irrigation, Experiment 2, Irrigation 1.

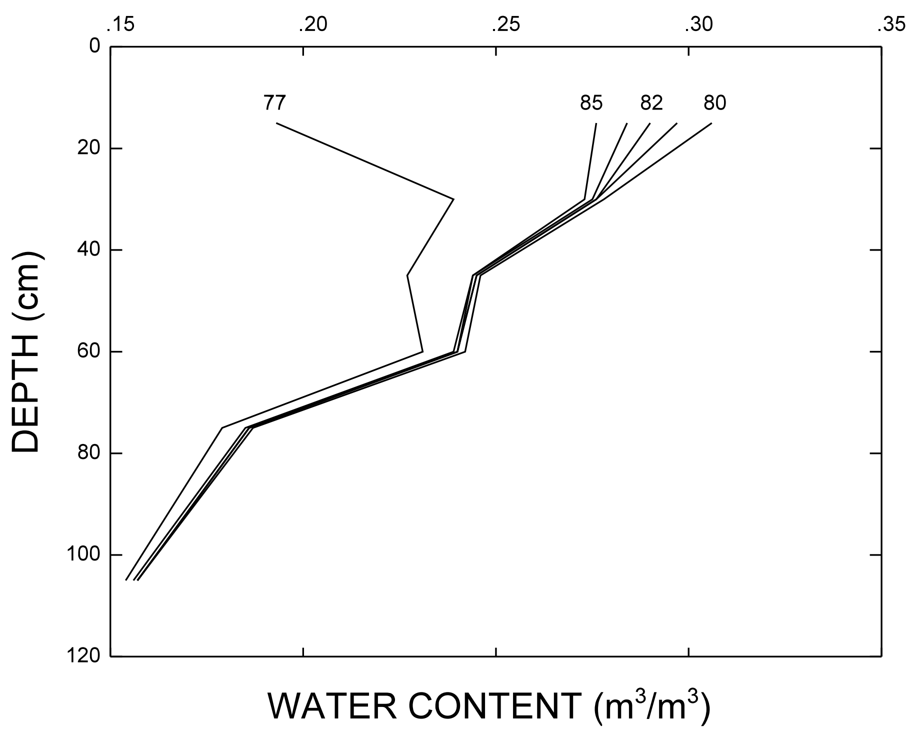

Figure 3-14. Average daily water content profiles before and after Irrigation 1, Experiment 2. Numbers are day of year.

Average soil water content changed most in the top layer where it increased from 0.19 to 0.31 m^3/m^3 due to irrigation (Figure 3-14, Table 3-6). By contrast the water content at 105 cm changed hardly at all, increasing from 0.15 to 0.16 m^3/m^3. As the soil dried the largest changes in water content again occurred in the surface layer while water content at 105 cm remained constant at 0.16 m^3/m^3. Water content in intermediate layers also changed little suggesting that drainage was uniform from 30 cm depth downward.

Table 3-6.

Average soil water contents (m^3/m^3) by day and depth, Experiment 2, Irrigation 1.

Depth (cm)	15	30	45	60	75	105
Day 77. Count = 57.						
Average	0.193	0.239	0.227	0.231	0.179	0.154
Maximum	0.266	0.280	0.314	0.349	0.291	0.369
Minimum	0.100	0.171	0.120	0.072	0.064	0.062
Day 80. Count = 57.						
Average	0.306	0.278	0.246	0.242	0.187	0.157
Maximum	0.381	0.360	0.365	0.357	0.307	0.374
Minimum	0.164	0.176	0.127	0.076	0.067	0.062
Day 81. Count = 56.						
Average	0.297	0.276	0.245	0.240	0.186	0.157
Maximum	0.356	0.358	0.361	0.355	0.303	0.369
Minimum	0.163	0.174	0.131	0.079	0.070	0.064
Day 82. Count = 57.						
Average	0.290	0.276	0.245	0.240	0.186	0.157
Maximum	0.344	0.353	0.358	0.357	0.309	0.374
Minimum	0.158	0.175	0.128	0.075	0.068	0.063
Day 83. Count = 57.						
Average	0.284	0.275	0.244	0.240	0.186	0.157
Maximum	0.334	0.356	0.352	0.360	0.310	0.376
Minimum	0.159	0.178	0.130	0.073	0.073	0.063
Day 85. Count = 57.						
Average	0.276	0.273	0.244	0.239	0.185	0.156
Maximum	0.328	0.347	0.349	0.355	0.311	0.377
Minimum	0.145	0.179	0.127	0.077	0.066	0.062

The second irrigation applied 2.08 cm of water as measured by catch cans but the change in moisture stored in the 1.2 m profile averaged only 0.89 cm. The difference of 1.1 cm was probably largely due to drainage. Evaporation could have accounted for some of the difference since neutron scattering was not finished until 13:55 on the day after irrigation and potential evapotranspiration was 0.7 cm for the day. There appeared to be some correlation between low catch can depths and low change in storage (Figure 3-15).

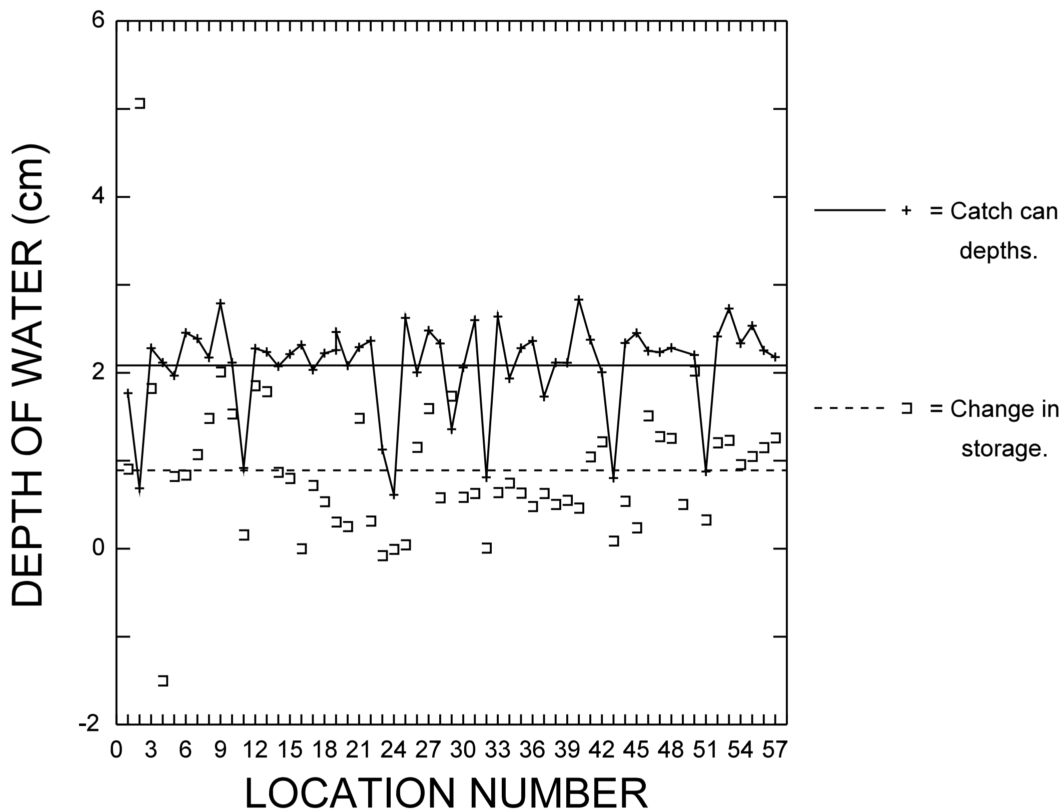

Figure 3-15. Catch can depths and change in storage due to Irrigation 2, Experiment 2.

Again the greatest water content changes occured in the top layer with Θ_v increasing from 0.27 to 0.30 m^3/m^3 due to irrigation while Θ_v at 105 cm remained constant at 0.16 m^3/m^3 (Table 3-7, Figure 3-16). After irrigation the water content of the surface layer declined over 9 days to its original water content of 0.27 m^3/m^3 while the subsurface water contents remained nearly constant, again suggesting nearly uniform drainage in the soil below 30 cm depth.

Table 3-7.

Daily average water contents (m^3/m^3) at 15, 30, 45, 60, 75, 90 and 105 cm, Irrigation 2, Experiment 2.

Depth (cm)	15	30	45	60	75	90	105
Day 90. Count = 57.							
Average	0.269	0.272	0.243	0.239	0.185	0.181	0.156
Maximum	0.365	0.344	0.342	0.355	0.316	0.350	0.371
Minimum	0.139	0.178	0.129	0.075	0.065	0.078	0.065
Day 92. Count = 57.							
Average	0.301	0.278	0.246	0.240	0.185	0.182	0.156
Maximum	0.443	0.350	0.345	0.365	0.318	0.356	0.371
Minimum	0.152	0.176	0.135	0.076	0.071	0.079	0.061
Day 93. Count =57.							
Average	0.313	0.277	0.245	0.240	0.187	0.184	0.156
Maximum	0.886	0.349	0.345	0.372	0.316	0.357	0.370
Minimum	0.145	0.181	0.133	0.077	0.067	0.080	0.062
Day 94. Count = 57.							
Average	0.284	0.280	0.249	0.247	0.188	0.183	0.157
Maximum	0.352	0.343	0.342	0.361	0.311	0.354	0.371
Minimum	0.146	0.182	0.137	0.107	0.067	0.080	0.062
Day 95. Count = 57.							
Average	0.282	0.277	0.245	0.240	0.185	0.181	0.156
Maximum	0.346	0.351	0.342	0.364	0.312	0.354	0.373
Minimum	0.139	0.177	0.129	0.076	0.069	0.080	0.062
Day 96. Count = 57.							
Average	0.280	0.276	0.245	0.239	0.184	0.181	0.155
Maximum	0.345	0.342	0.343	0.364	0.321	0.348	0.376
Minimum	0.144	0.178	0.131	0.078	0.069	0.076	0.063
Day 98. Count = 57.							
Average	0.275	0.276	0.245	0.240	0.184	0.181	0.155
Maximum	0.338	0.342	0.338	0.362	0.312	0.350	0.371
Minimum	0.134	0.180	0.130	0.081	0.068	0.080	0.064
Day 100. Count = 57.							
Average	0.269	0.276	0.245	0.240	0.185	0.178	0.154
Maximum	0.330	0.337	0.332	0.361	0.311	0.297	0.369
Minimum	0.130	0.181	0.133	0.076	0.067	0.080	0.064

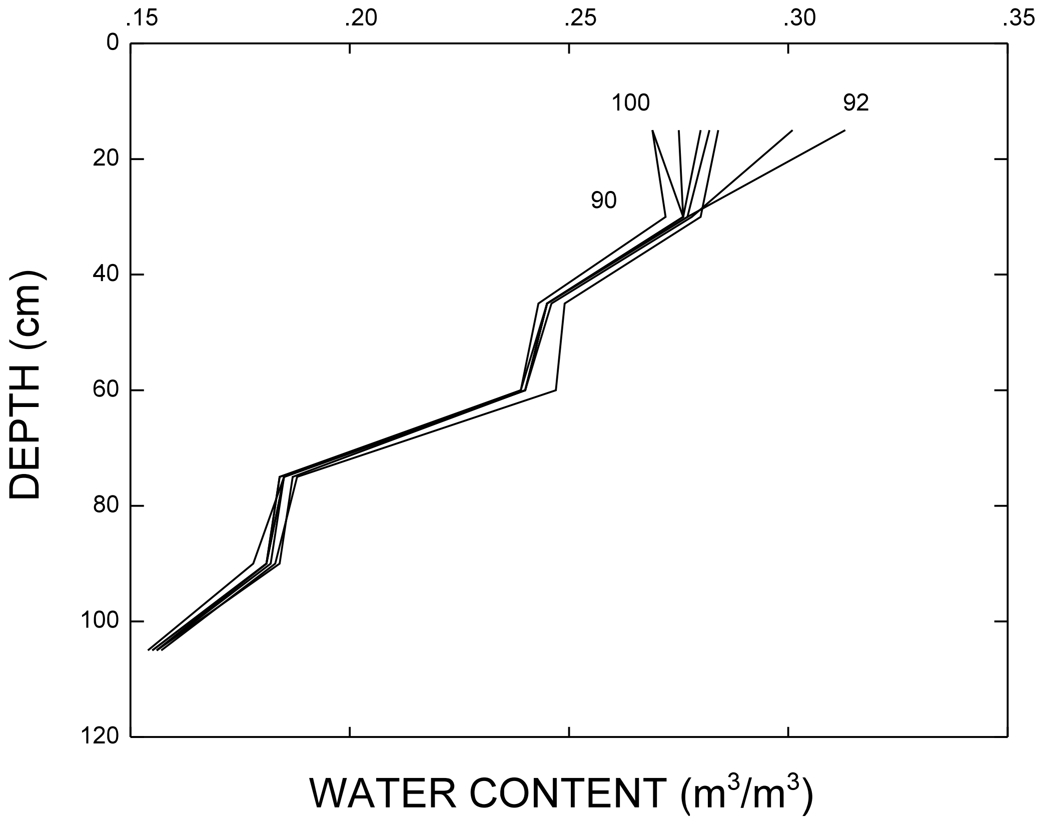

Figure 3-16. Average daily water content profiles before and after Irrigation 2, Experiment 2. Numbers are day of year.

The third irrigation was the smallest, averaging 1.60 cm as measured by catch cans. As for the second irrigation, the change in storage, at 0.75 cm, was less than half of the irrigation depth (Figure 3-17). Moisture in the surface layer increased from 0.27 to 0.30 m^3/m^3 while that in deeper layers remained essentially constant. During the four days of measurement after irrigation the surface soil dried while that at 30 cm and below remained at essentially the same moisture content, again indicating uniform drainage in the subsurface layers (Figure 3-18, Table 3-8).

Table 3-8.

Average daily water contents (m^3/m^3) at 15, 30, 45, 60, 75, 90 and 105 cm, Irrigation 3, Experiment 2.

Depth (cm)	15	30	45	60	75	90	105
Day 100. Count = 55.							
Average	0.269	0.276	0.245	0.240	0.185	0.178	0.154
Maximum	0.330	0.337	0.332	0.361	0.311	0.297	0.369
Minimum	0.130	0.181	0.133	0.076	0.067	0.080	0.064
Day 102. Count = 57.							
Average	0.297	0.279	0.246	0.241	0.185	0.181	0.155
Maximum	0.621	0.403	0.342	0.366	0.314	0.344	0.363
Minimum	0.137	0.180	0.131	0.081	0.069	0.076	0.062
Day 103. Count = 57.							
Average	0.282	0.276	0.246	0.240	0.186	0.181	0.155
Maximum	0.348	0.343	0.336	0.364	0.312	0.339	0.367
Minimum	0.139	0.182	0.133	0.079	0.068	0.076	0.064
Day 105. Count = 55.							
Average	0.281	0.275	0.245	0.238	0.183	0.181	0.158
Maximum	0.430	0.340	0.335	0.347	0.315	0.337	0.366
Minimum	0.135	0.182	0.134	0.079	0.066	0.078	0.065

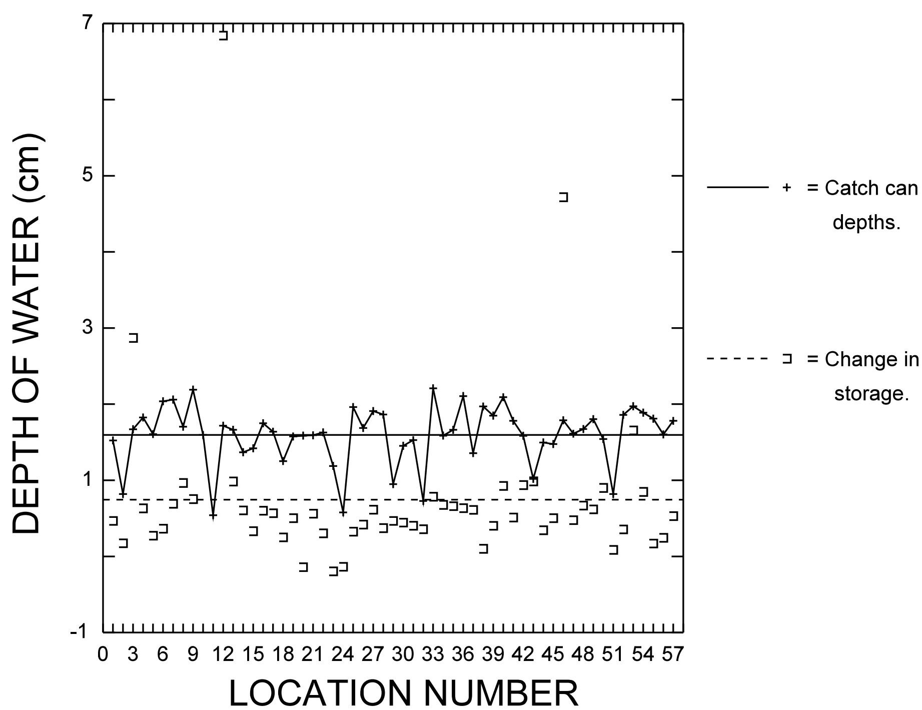

Figure 3-17. Catch can depths and change in storage due to irrigation for Irrigation 3, Experiment 2.

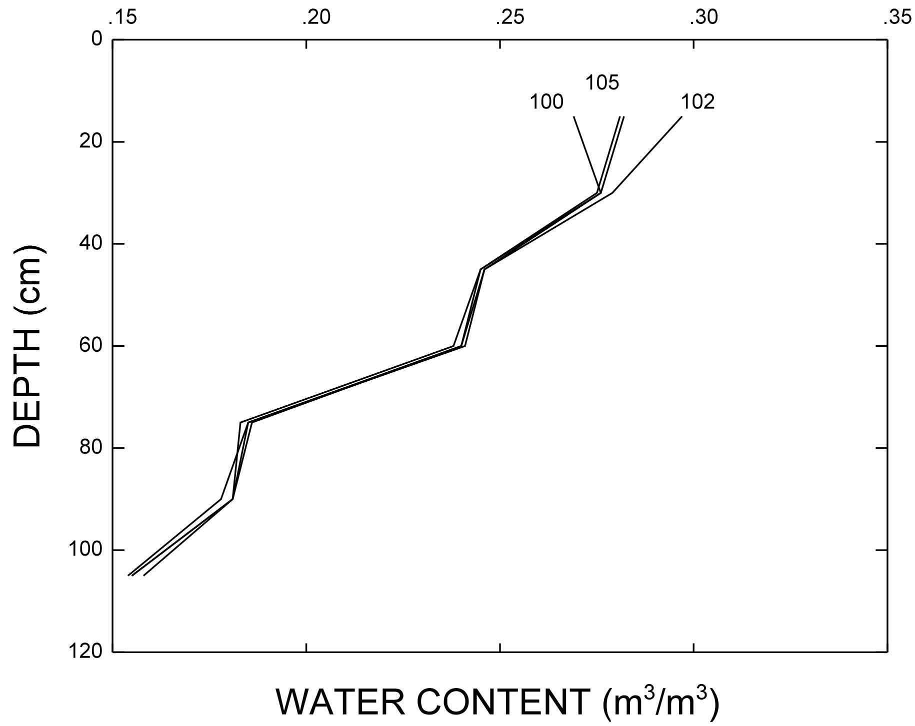

Figure 3-18. Average daily water content profiles before and after Irrigation 3, Experiment 2. Numbers are day of year.

Irrigation Uniformity.

Two of the most common methods of expressing irrigation uniformity are Christiansen's uniformity coefficient (UCC) and the Lower Quarter Distribution Uniformity (LQDU). Christiansen's uniformity coefficient is calculated by

$$UCC = 1 - \Sigma|x_i - \bar{x}|/\bar{x} \qquad [3\text{-}1]$$

where the x_i are the individual measured depths of irrigation and $\bar{x}$ is the average depth of irrigation. The LQDU is calculated by

$$LQDU = \text{Average of the lowest quarter of depths}/\bar{x} \qquad [3\text{-}2]$$

The UCC and LQDU equations were applied to three sets of data for each irrigation - catch can depths, change in storage due to irrigation, and profile water content on the day after irrigation, all in cm (Table 3-9). The change in storage was calculated by subtracting the profile water content for the day before irrigation from that for the day after irrigation.

For the first irrigation catch cans were arranged in three different ways - perpendicular to the sprinkler lateral and extending inward 30 m from the field edge (15 cans), parallel to the lateral at a distance 30 m from the field edge (26 cans), and at the 57 neutron access tube locations scattered across the field (Figure 2-4). Mean depths and uniformities were quite similar for the cans at access tube locations and parallel to the lateral with mean depths of 4.16 and 4.28 cm, and UCC of 0.84 and 0.83, respectively. The cans perpendicular to the sprinkler lateral showed the edge effect due to some cans being at the outer edge of the sprinkler pattern at startup. Therefore the low mean depth of 3.68 cm and UCC of 0.72 were not considered typical of the field as a whole.

UCC values calculated from catch can data for the second and third irrigations were close to those from the first irrigation and to the global average of 0.82, showing that the sprinkler system performed similarly for all irrigations.

LQDU values based on catch can data were also similar for the three irrigations and were close to the global average of 0.66 regardless of whether the data came from access tube locations or from the transect parallel to the lateral. From these UCC and LQDU values the irrigation system would be evaluated as acceptably uniform.

Table 3-9.

Christiansen's uniformity coefficient (UCC), the lower quarter distribution uniformity (LQDU) and water depths (cm) for three irrigations, Experiment 2. The UCC, LQDU and water depth values were calculated for three variables - change in storage due to irrigation, depth of water in catch cans and profile water content after irrigation. N is number of samples.

Irrigation 1.	UCC	LQDU	Depth (cm)	C.V.	N
Catch cans:					
At access tubes	0.84	0.68	4.16	0.230	57
Parallel lateral	0.83	0.64	4.28	0.248	26
Perpendicular	0.72	0.52	3.68	0.329	15
Change in storage:	0.57	0.38	3.86	0.597	57
Profile water content:	0.83	0.70	27.29	0.214	57
Irrigation 2.					
Catch cans:					
At access tubes	0.82	0.64	2.08	0.257	57
Parallel lateral	0.81	0.63	2.04	0.259	40
Change in storage:	0.31	0.25	0.75	0.864	55
Profile water content:	0.82	0.71	27.12	0.206	55
Irrigation 3.					
Catch cans:					
At access tubes	0.83	0.67	1.60	0.239	57
Parallel lateral	0.81	0.67	1.51	0.242	51
Change in storage:	0.40	0.17	0.92	1.453	57
Profile water content:	0.82	0.72	27.25	0.213	57

Examination of the profile water contents told much the same story. On the day after each irrigation the average profile water content was just over 27 cm. Since the irrigations ranged from 1.60 to 4.16 cm the similarity of profile water contents leads to the conclusion that the field was at "field capacity" after each irrigation. Applying the UCC and LQDU equations to the profile water contents resulted in quite similar UCC and LQDU values for all irrigations, with averages of 0.82 and 0.71, respectively. While the UCC values were very close to those calculated from catch can data, the LQDU values were significantly higher than LQDU values from catch cans indicating that the extremes of application were modified by redistribution of soil moisture. This was indicative of the fact that, although UCC values were very similar for both catch can data and profile water contents, the profile water contents were not necessarily a result of the application depths.

Evidence that the catch can depths and profile water contents were not linked was provided by the UCC and LQDU values for change in storage. UCC values ranged from 0.31 for the last irrigation to 0.57 for the first, much lower than UCC values from either catch cans or profile water contents. LQDU values ranged from 0.17 for the second irrigation to 0.38 for the first, also much lower than LQDU values from catch cans and post-irrigation profile water contents. Ponding occurred everywhere in the field for all three irrigations so a major mechanism of redistribution was overland flow.

<u>Infrared Thermometry.</u>

Field soil temperatures were measured with an infrared thermometer by scanning in a circle around the neutron access tubes. For each of the three irrigation cycles midday temperatures averaged the lowest on the first day after irrigation. Midday temperatures were irregular thereafter, reflecting changes in cloud cover, especially on day 84 which became overcast at 12:30, and day 93 (Table 3-10, Figure 3-19). The presence of cloud cover on days 80, 84, 88, 93 and 98 was reflected by the reduced solar radiation recorded on those days (Figure 3-19). Midday reference dry soil temperatures generally reflected the same trends in cloud cover except for day 98 when cloud cover did not appear until after the midday IRT readings. For each cycle the difference between midday reference dry soil and field soil temperatures ($T_{o,max}$ - $T_{d,max}$), which is correlated with evaporation rate, was largest on the first 2 days after irrigation but decreased on subsequent days as expected. The lower value of ($T_{o,max}$ - $T_{d,max}$) on day 80 compared to day 81 was due to cloudiness on day 80 that limited potential evapotranspiration.

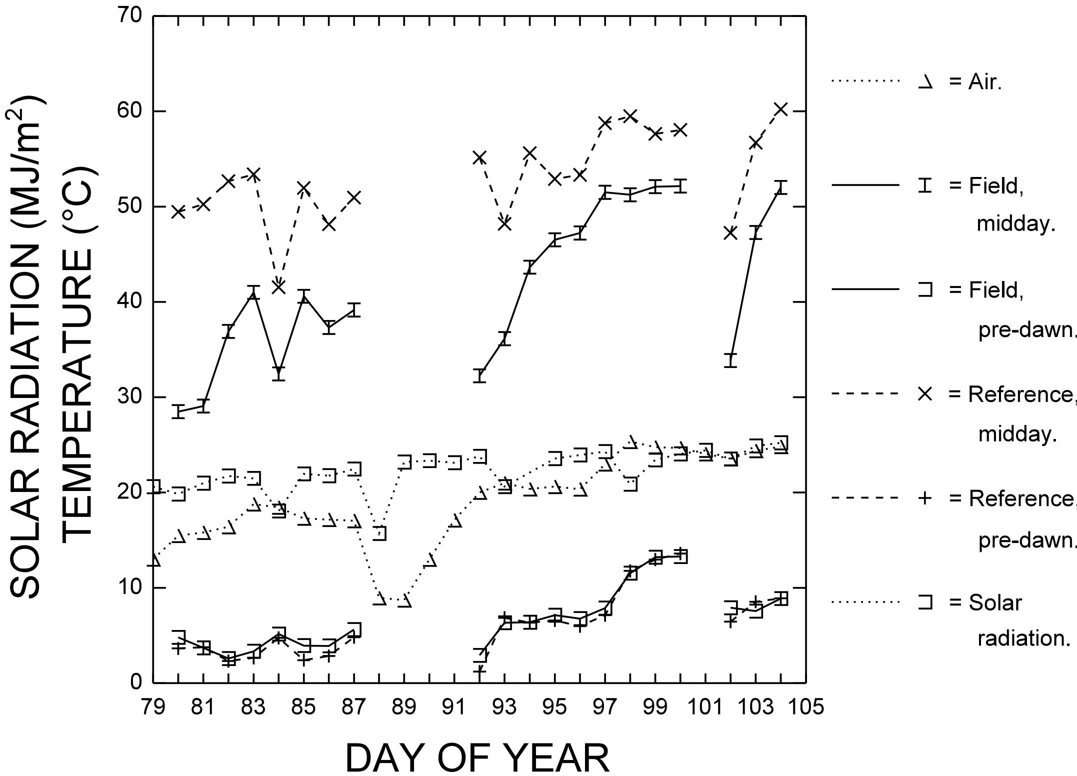

Figure 3-19. Average daily field and reference dry soil temperatures measured by IRT at pre-dawn and midday.

Pre-dawn infrared thermometry showed that field and reference dry soil temperatures averaged within 1.5 °C of each other (Tables 3-10 and 3-11, Figure 3-19).

Standard deviations (S.D.) of both reference dry soil and field soil temperatures generally were less than 1 °C for pre-dawn measurements. Probably because the soil was flat and uniform in grain size, the S.D. of reference dry soil was also less than 1 for midday measurements. By contrast the S.D. of field soil temperatures was usually greater than 1, and was greater than 2 on 12 of the 19 days measured.

Also shown in Table 3-10 are the averages of the S.D. for the individual field soil temperatures. Recall that the measurement at each access tube was accomplished by scanning around the tube while the infrared thermometer took 50 readings. The average and S.D. of these readings were recorded for each tube. The average of these S.D. of the individual temperature measurements was, on 15 out of 18 days, larger than the S.D. of the combined field soil temperatures. Thus it appears that the variability in individual measurements was greater than the variability of temperature across the field. The 3 days, for which variability at a location was on average lower than variability across the field, were on the days after the second and third irrigations and on day 84 which was characterized by an even distribution of high clouds.

Temperatures of reference dry soils were taken both before and after those in the field. The second pre-dawn measurement was sometimes as much as 3 °C higher than the first, indicating that the soil was warming as measurements were taken in the field. At midday the reference measurements were often even further apart with differences of up to 10 °C on cloudy days such as day 84 but with differences of 1 to 3 °C on other days as well (Table 3-11, data shown for first irrigation cycle only).

Table 3-10.

Average daily pre-dawn and midday infrared thermometer readings (°C) and ($T_{o,max}$ - $T_{d,max}$), Experiment 1.

	Field: Pre-dawn IRT	Field: Pre-dawn IR S.D.	Field: Midday IRT	Field: Midday IR S.D.	Reference Dry Soil: Midday IRT	Reference Dry Soil: Midday IR S.D.	$T_{o,max}-T_{d,max}$
Day 79.	First Irrigation						
Day 80.							
Average	4.80	0.289	28.49	0.892	49.46	0.20	20.97
S.D.	0.432		0.694				0.694
Day 81.							
Average	3.70	0.130	29.08	3.188	50.25	0.091	21.16
S.D.	0.479		2.919				2.919
Day 82.							
Average	2.58	0.125	36.91	3.705	52.68	0.157	15.77
S.D.	0.364		2.226				2.226
Day 83.							
Average	3.34	0.117	41.01	3.286	53.39	0.200	12.38
S.D.	0.334		1.429				1.429
Day 84.							
Average	5.15	0.125	32.46	0.690	41.55	0.075	9.09
S.D.	0.363		2.379				2.379
Day 85.							
Average	3.94	0.238	40.60	2.574	51.97	0.550	11.37
S.D.	0.352		1.044				1.044
Day 86.							
Average	3.91	0.192	37.32	1.716	48.15	0.114	10.83
S.D.	0.594		1.355				1.355
Day 87.							
Average	5.62	0.134	39.16	1.823	50.95	0.143	11.80
S.D.	0.339		1.110				1.110
Day 91.	Second Irrigation						
Day 92.							
Average	2.92	0.218	32.26	1.584	55.16	0.070	22.90
S.D.	0.518		4.187				4.187
Day 93.							
Average	6.34	0.047	36.15	2.497	48.20	0.041	12.05
S.D.	0.592		2.431				2.431
Day 94.							
Average	6.39	0.097	43.65	1.904	55.62	0.054	11.97
S.D.	0.430		1.264				1.264
Day 95.							
Average	7.13	0.153	46.53	2.010	52.91	0.040	6.38
S.D.	0.340		1.362				1.362
Day 96.							
Average	6.77	0.160	47.24	2.159	53.34	0.034	6.10
S.D.	0.390		1.289				1.289
Day 97.							
Average	7.87	0.144	51.51	2.386	58.77	0.046	7.26
S.D.	0.311		1.230				1.230
Day 98.							
Average	11.54	0.092	51.25	-----	59.50	0.041	8.25
S.D.	0.285		1.278				1.278
Day 99.							
Average	13.21	0.086	52.10	1.784	57.64	0.099	5.53
S.D.	0.273		0.938				0.938
Day 100.							
Average	13.29	0.070	52.16	2.482	58.06	0.036	5.89
S.D.	0.229		2.175				2.175

Table 3-10. (cont.)

	Field: Pre-dawn IRT	Field: Pre-dawn IR S.D.	Field: Midday IRT	Field: Midday IR S.D.	Reference Dry Soil: Midday IRT	Reference Dry Soil: Midday IR S.D.	$T_{o,max}-T_{d,max}$
Day 101.	Third Irrigation						
Day 102.							
Average	7.91	0.260	33.85	2.482	47.25	0.045	14.20
S.D.	0.592		4.831				3.501
Day 103.							
Average	7.56	0.103	47.30	2.016	56.72	0.071	9.42
S.D.	0.516		1.679				1.679
Day 104.							
Average	8.88	0.129	52.02	2.253	60.23	0.063	8.21
S.D.	0.330		1.619				1.619

These changes in soil temperature, over the course of IRT measurements, were confirmed by measuring the temperatures of the same 3 field sites both at the beginning and end of measurements on several occasions (Table 3-12). The temperature change ranged from -6 °C at midday of day 84 to 0.59 °C for pre-dawn measurements on day 87. Thus it cannot be assumed that field soil temperatures were essentially constant over the approximately 40 minutes required to measure surface temperatures at all 57 access tubes.

After both the second and third irrigations, midday field soil surface temperatures were lowest on the first day after irrigation, at about 32 °C, and increased to a maximum of about 52 °C (Figure 3-19, Table 3-10). This increase took much less time after the third irrigation which was smaller than the second (1.60 vs. 2.08 cm). Potential evapotranspiration was also about 2 mm per day higher after the third irrigation than it was after the second due to higher air temperatures and lower relative humidity (Table 3-13).

Table 3-11.

Reference dry soil infrared thermometer readings (°C), Irrigation 1, Experiment 2.

	Location	Pre-dawn Reading	S.D.	Location	Midday Reading	S.D.
Day 80.						
	100	3.94	0.004	101	44.65	0.093
	101	3.64	0.003	101	46.48	0.273
				101	51.32	0.049
				Average	47.48	0.140
				102	46.08	0.437
				102	51.04	0.039
				102	51.26	0.110
				Average	49.46	0.200
Day 81.						
	101	2.47	0.006	101	45.50	0.055
	101	5.83	0.006	101	45.74	0.085
	Average	4.15	0.006	Average	45.62	0.070
	102	2.17	0.005	102	49.87	0.085
	102	5.36	0.002	102	50.62	0.097
	Average	3.77	0.003	Average	50.25	0.091
Day 82.						
	101	2.14	0.008	101	47.01	0.051
	101	4.54	0.002	101	49.11	0.159
	Average	3.34	0.005	Average	48.06	0.105
	102	1.19	0.008	102	51.31	0.176
	102	3.44	0.001	102	54.05	0.137
	Average	2.32	0.004	Average	52.68	0.157
Day 83.						
	101	2.37	0.010	101	50.30	0.169
	101	4.39	0.002	101	50.68	0.113
	Average	3.38	0.006	Average	50.49	0.141
	102	1.69	0.004	102	52.41	0.204
	102	3.62	0.002	102	54.38	0.197
	Average	2.66	0.003	Average	53.39	0.200
Day 84.						
				101	35.98	0.006
	101	5.70	0.005	101	37.37	0.024
	101	5.82	0.003	101	43.34	0.249
	Average	5.76	0.004	Average	38.90	0.093
				102	37.61	0.023
	102	4.69	0.002	102	39.08	0.187
	102	4.80	0.003	102	47.97	0.015
	Average	4.75	0.002	Average	41.55	0.075
Day 85.						
	101	3.35	0.006	101	46.76	0.053
	101	4.27	0.001	101	47.08	0.014
	Average	3.81	0.003	Average	46.92	0.033
				102	51.54	0.117
	102	1.71	0.002	102	51.91	0.099
	102	3.12	0.001	102	52.45	1.435
	Average	2.42	0.001	Average	51.97	0.550

Table 3-11 (cont.).

Reference dry soil infrared thermometer readings (°C), Irrigation 1, Experiment 2.

	Location	Pre-dawn Reading	S.D.	Location	Midday Reading	S.D.
Day 86.						
				101	40.16	0.027
	101	2.05	0.003	101	40.56	0.237
	101	5.75	0.006	101	45.00	0.022
	Average	3.90	0.004	Average	41.91	0.095
				102	43.18	0.154
	102	1.18	0.006	102	50.34	0.144
	102	4.50	0.001	102	50.94	0.044
	Average	2.84	0.003	Average	48.15	0.114
Day 87.						
	101	5.3	0.004	101	42.07	0.072
	101	5.89	0.001	101	42.51	0.064
	Average	5.59	0.003	Average	42.29	0.068
	102	4.65	0.004	102	50.38	0.162
	102	4.99	0.001	102	51.52	0.124
	Average	4.82	0.002	Average	50.95	0.143

Weather.

Weather was unstable during the experiment with a rainstorm on day 88 which effectively ended data gathering for the first irrigation cycle (Table 3-13, Figures 3-20 & 3-21). Periods of cloudiness affected the first few days of the first cycle. The increasing potential ET during the first cycle was due to both increasing wind speeds and increasing solar radiation as skies cleared.

Table 3-12.

Field temperatures at 3 locations before and after field IRT measurements, and differences between before and after IRT measurements (°C), Irrigation 1, Experiment 2.

	Before			After			
Location	Temp.	S.D.	Time	Temp.	S.D.	Time	Difference
Day 84.							
1	38.22	1.549	12:31	31.61	0.679	13:13	-6.61
43	36.56	1.928	12:32	31.60	0.931	13:14	-4.96
2	36.89	1.653	12:33	30.47	0.379	13:16	-6.42
						Average:	-6.00
Day 85.							
1	3.36	0.211	5:53	4.69	0.193	6:31	1.33
43	3.80	0.353	5:54	4.93	0.172	6:32	1.13
2	3.75	0.163	5:54	4.93	0.124	6:32	1.18
						Average:	1.21
Day 86.							
1	2.48	0.199	5:48	4.94	0.115	6:25	2.46
43	2.81	0.228	5:49	4.90	0.120	6:26	2.09
2	2.84	0.215	5:50	5.03	0.102	6:27	2.19
						Average:	2.25
1	36.22	1.088	12:27	40.42	1.162	13:05	4.20
43	35.85	1.723	12:29	38.56	4.118	13:06	2.71
2	36.17	2.664	12:29	39.89	3.185	13:06	3.72
						Average:	3.54
Day 87.							
1	4.84	0.101	5:41	5.67	0.135	6:19	0.83
43	5.31	0.122	5:42	5.91	0.150	6:20	0.60
2	5.38	0.094	5:43	5.72	0.118	6:20	0.34
						Average:	0.59
1	39.25	1.245	12:29	40.84	0.726	13:07	1.59
43	37.83	2.068	12:30	39.16	3.952	13:07	1.33
2	38.49	1.541	12:31	39.21	2.352	13:08	0.72
						Average:	1.21

Average daily wind speed varied from 1.5 to 4.9 m/s. Daytime wind speeds were higher than at nighttime until day 96 after which they were about equal. Net radiation and average air temperature were closely linked and tended to be lowest on cloudy days such as days 78, 88 and 84.

Table 3-13.

Daily meteorological statistics and potential evapotranspiration, Experiment 2.
Average air temperature, average relative humidity (RH), average wind speed, total solar (R_s) and net (R_n) radiation, precipitation, and potential evapotranspiration (ET_p) calculated on a daily and a half-hourly basis. Wind speeds corrected to 2 m height (see Appendix A).

Day	Ave. Air Temp. (°C)	Ave. RH (%)	Ave. Wind --- (m/s) ---	Ave. Daytime Wind	Total R_s --- (MJ/m^2) ---	Total R_n	Precip. (mm)	Daily Basis ET_p (mm)	1/2 h Basis ET_p (mm)
78	10.62	23.69	1.96	2.30	8.42	0.75	0	3.21	2.72
79	13.01	46.59	1.40	1.89	20.62	9.44	Irriga.	4.16	4.53
80	15.48	49.19	2.08	2.74	19.85	8.73	0	4.67	4.86
81	15.81	38.97	2.06	2.65	20.99	9.65	0	5.43	5.60
82	16.41	33.07	1.98	2.31	21.74	10.24	0	5.87	5.94
83	18.79	30.71	1.99	2.61	21.49	10.08	0	6.30	6.45
84	18.45	26.39	3.02	4.03	18.06	7.31	0	6.95	7.36
85	17.29	26.22	2.19	3.39	21.96	10.50	0	6.64	7.19
86	17.17	30.09	2.75	3.77	21.77	10.12	0	6.94	7.36
87	17.04	38.93	4.54	5.46	22.47	10.79	0	8.25	8.74
88	8.94	59.16	3.38	4.32	15.71	5.80	2	3.50	3.99
89	8.71	49.21	1.76	2.43	23.20	11.39	0	4.23	4.97
90	12.99	43.13	2.16	2.83	23.35	11.51	0	5.37	6.05
91	17.11	37.44	1.55	1.69	23.13	11.44	Irriga.	5.65	5.99
92	20.01	26.57	1.49	1.69	23.80	11.90	0	6.58	6.76
93	21.00	25.59	2.26	2.91	20.63	9.32	0	7.03	6.92
94	20.37	22.99	----	----	-----	-----	0	----	----
95	20.63	26.40	1.81	2.38	23.57	11.33	0	6.92	6.98
96	20.36	29.76	2.08	2.13	23.94	11.48	0	7.08	7.11
97	22.98	27.71	1.99	2.06	24.30	12.13	0	7.66	7.65
98	25.35	24.93	3.05	3.10	20.88	11.11	0	9.40	9.34
99	24.76	31.05	2.28	2.16	23.43	12.32	0	8.16	7.86
100	24.68	28.02	2.28	2.42	24.06	11.78	0	8.18	8.12
101	24.06	25.74	2.12	2.02	24.43	12.47	Irriga.	8.21	8.11
102	23.55	22.92	2.06	2.12	23.51	11.19	0	7.84	7.73
103	24.39	19.87	2.36	2.16	24.89	12.22	0	8.91	8.83
104	24.83	18.48	2.26	2.12	25.23	12.12	0	8.91	8.86

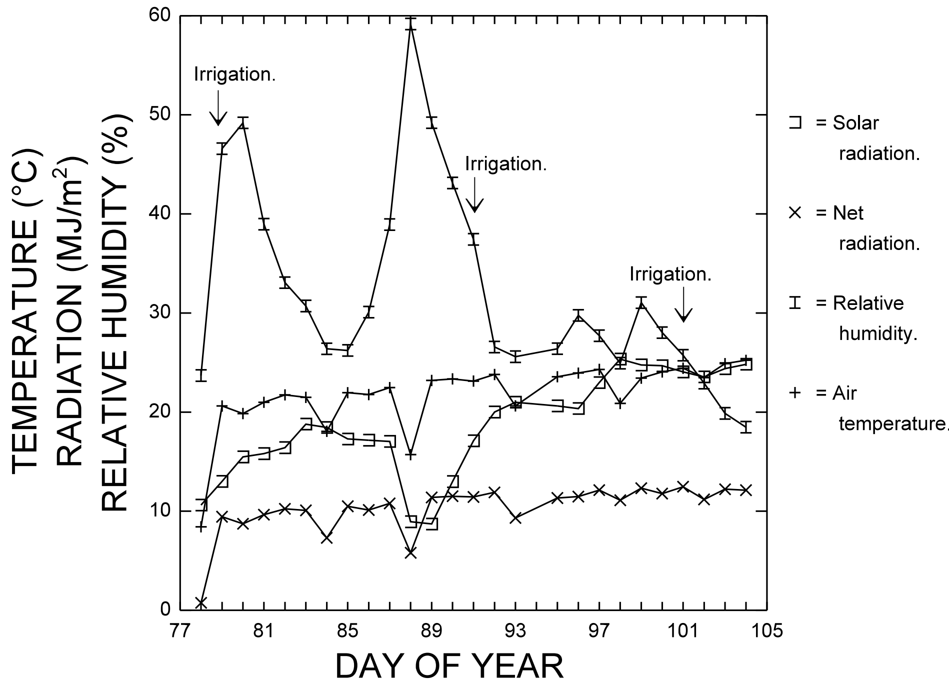

Figure 3-20. Average daily relative humidity and air temperature, and total daily net and solar radiation, Experiment 2.

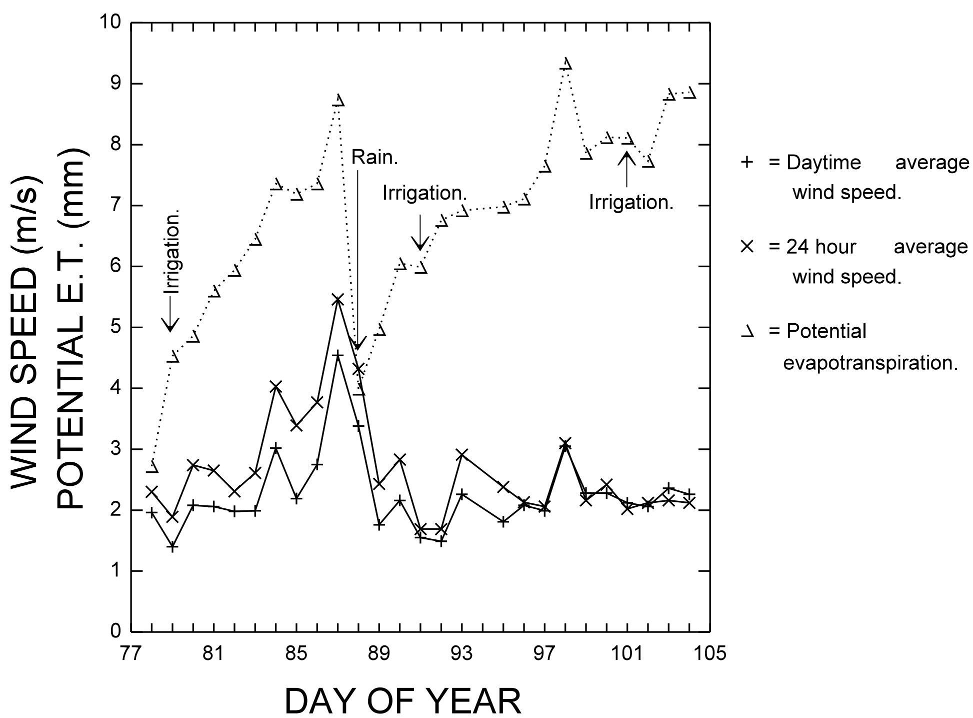

Figure 3-21. Average daily daytime and 24 hour wind speeds, and potential evapotranspiration, Experiment 2.

Experiment 3

The Third Experiment consisted of two irrigations and subsequent periods of measurement during which evaporation was measured by microlysimetery and data were gathered to enable use of the energy balance model of evaporation.

First Run.

During the first run, consisting of the first irrigation and subsequent measurements, there were rains totaling 8 mm on days 306 and 307 and 3 mm of rain on day 310. The maximum evaporation measured was always less than the potential evapotranspiration (calculations shown in Appendix A) (Figure 3-22). Removal and weighing of ML's on the first day after irrigation was not finished until 11:30 AM due the large number of ML's to be extracted and cleaned and failure of the extraction equipment.

Due to the tardy extraction, infrared temperatures were not taken on the first day. Soil temperatures measured by thermistor were lost due to a programming error on the data logger. Wind speeds were highly variable with average daytime wind speeds of over 5 m/s on days 304, 310 and 317 contributing to potential evapotranspiration rates of over 10 mm for those days (Table 3-14).

Table 3-14.

First run, Experiment 3 daily values. Measured (Evap.) and potential (ET_p) evaporation, average morning (Min T_d) and midday IR temperatures (Max T_d), 24 hour and daytime average wind, precipitation, and average air temperature. Wind corrected to 2 m height (see Appendix A).

Julian day	Max. Evap. (mm)	Min. Evap. (mm)	Ave. Evap. (mm)	Min. T_d (°C)	Max. T_d (°C)	Ave. Wind (m/s)	Daytime Wind (m/s)	ET_p (mm)	Precip. (mm)	Air Temp °C
303	10.5	2.5	5.7	---	---	2.82	3.02	11.5	0	20.85
304	11.7	1.7	5.6	8.24	29.63	4.76	6.75	19.5	0	21.57
305	4.0	0.2	1.1	10.62	27.22	2.33	3.07	7.3	0	17.10
306	---	---	---	---	---	1.95	2.56	2.5	1	13.37
307	---	---	---	---	---	2.08	2.08	2.0	7	12.52
308	3.5	1.7	2.7	10.50	23.51	2.51	2.67	4.7	0	15.40
309	3.8	1.2	2.2	4.86	26.63	1.66	1.90	5.0	0	14.43
310	1.7	-10.0	-4.1	6.66	28.62	4.11	4.88	10.9	3	16.99
311	3.5	2.1	2.8	5.31	20.24	2.35	2.30	5.9	0	12.38
312	3.8	1.0	1.8	1.13	25.25	2.30	2.52	6.1	0	10.90
313	3.8	0.6	1.4	1.37	27.02	2.19	2.78	6.3	0	12.08
314	2.7	0.6	1.2	4.82	27.80	2.12	2.69	6.2	0	13.43
315	2.1	0.6	1.1	4.95	29.54	2.25	2.74	7.1	0	14.37
316	1.7	0.6	1.2	4.05	28.64	1.72	1.70	5.7	0	15.76
317	2.1	0.6	1.3	10.54	26.67	4.21	5.16	12.3	0	18.47
318	1.0	0.2	0.6	6.88	31.54	3.52	3.54	8.7	0	16.62
319	1.0	0.2	0.6	12.94	23.11	1.57	1.19	3.6	0	17.22
320	1.0	0.4	0.7	9.62	25.00	1.83	1.96	4.2	0	16.66
321	0.8	0.2	0.5	10.84	24.32	1.93	2.10	4.5	0	18.03

Table 3-15.

Water balance for Run 1, Experiment 3.

	Depth (mm)	Water Content (m^3/m^3)	
Irrigation	23.0	----	
Microlysimeters			
Initial	89.7	0.296	
Final	73.3	0.242	
Change	16.4	0.054	<- evaporation.
Field			
Initial (ML)	89.7	0.296	
Final	70.9	0.234	
Change	18.8	0.062	<- evaporation + drainage.
ML final minus Field final	2.4	0.008	<- drainage.

Initial and final ML water contents averaged 0.296 and 0.242 m^3/m^3, respectively, giving a change of 0.054 m^3/m^3 or an average of 16.4 mm of water lost over the course of the run (Table 3-15). This was 71% of the 23 mm of water applied but just 18% of the 90 mm of water in the ML's just after irrigation. By contrast the final water content of the field, as measured by 18 volumetric samples to 30 cm depth, was 0.234 m^3/m^3. Assuming that initial water contents of ML's and field soil were equal, this amounted to a 0.062 m^3/m^3 change in

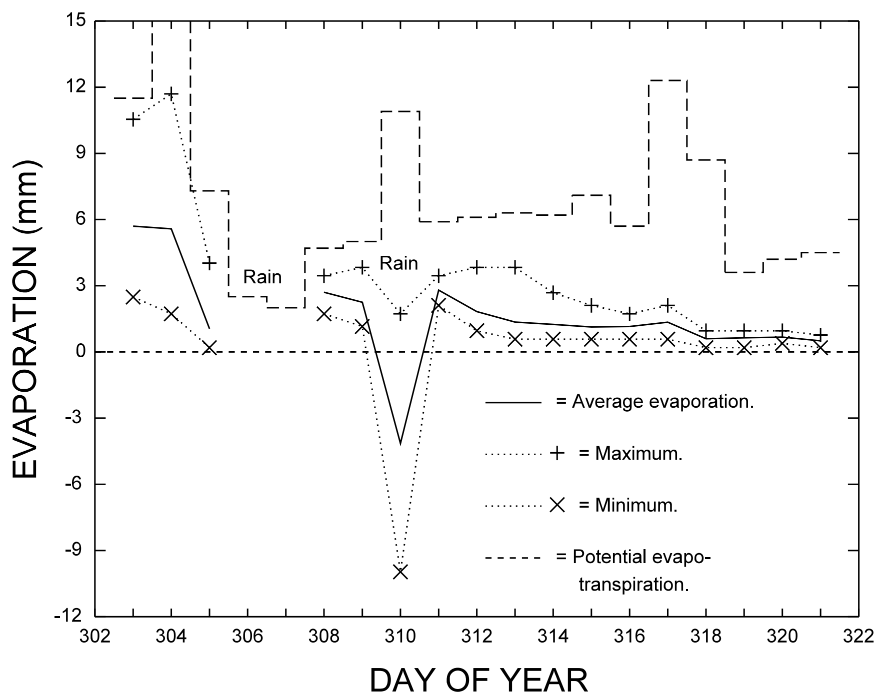

Figure 3-22. Maximum, minimum and average daily evaporation compared to potential evapo-transpiration, Run 1, Experiment 3.

storage, equivalent to 18.8 mm of water lost from a 30.3 cm deep profile. Subtracting 16.4 mm of evaporation from the 18.8 mm change in storage left 2.4 mm of water lost to drainage.

Second Run.

Data from the second experimental run of November - December 1986 are presented below. These data consisted of daily ML mass changes measured between 7 and 8 AM each day; meteorological data gathered on a 15 minute interval at weather stations situated at opposite ends of the field; soil temperature data recorded on a 15 minute basis at 0, 15 and 30 cm depth at a mid-field location; and ML and reference dry soil daily minimum and maximum temperatures measured by infrared thermometer. The 57 ML's were arranged in the field as shown in Figure 3-3. Irrigation was on day 328 and measurements were taken on days 329 through 338.

The soil - air temperature differences depicted in Figures 3-23 & 3-24 show that the air over the relatively warmer reference dry soil was unstable while that over the drying field was neutral or stable for most times. Wind speed at the site was highly variable (Figures 3-25 & 3-26). The dew point was never reached although it was approached closely at pre-dawn on some days (Figure 3-23). Average air and soil temperatures showed considerable fluctuation as cold and warm

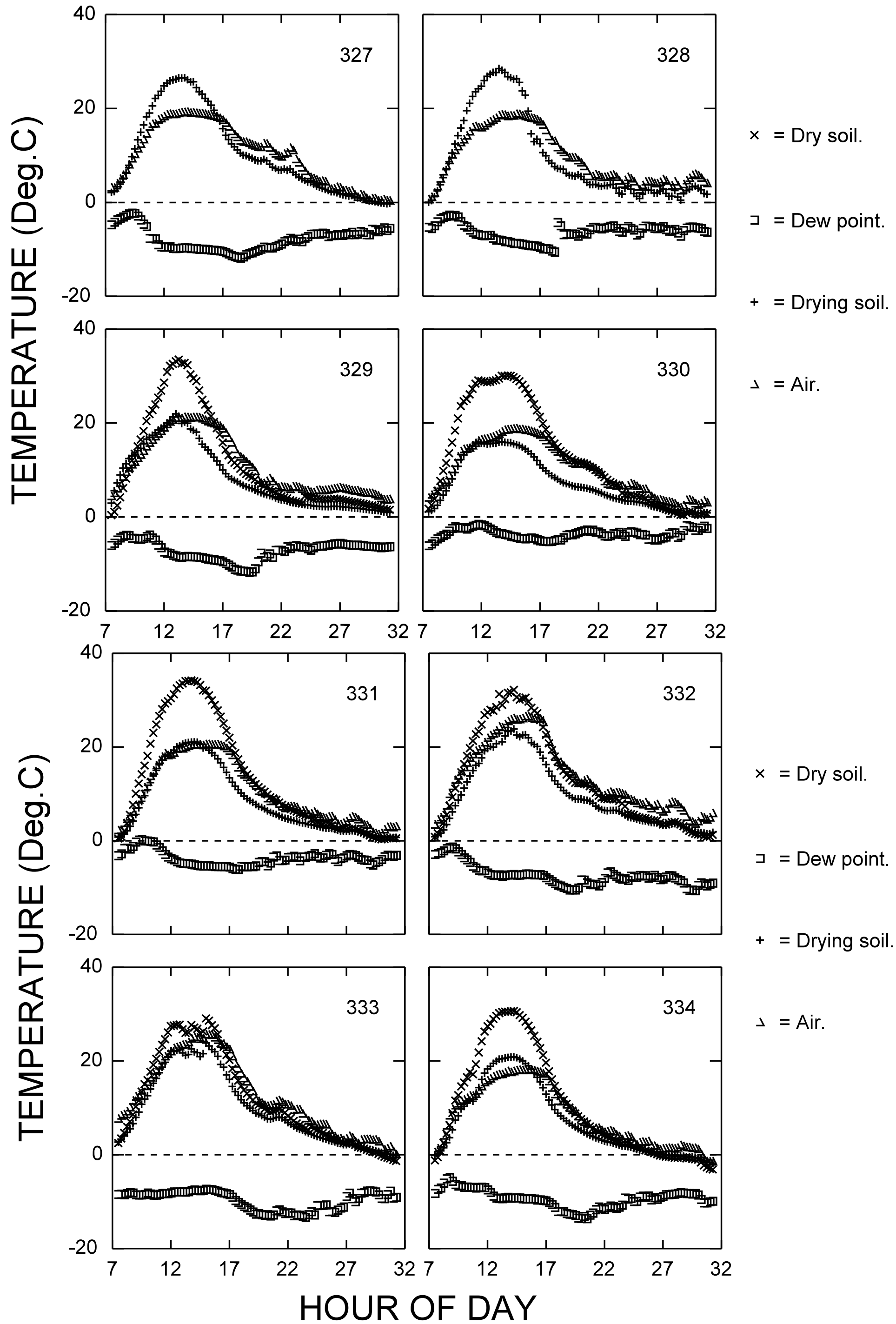

Figure 3-23. Dew point, soil and air temperatures for days 327 through 334, Run 2, Experiment 3.

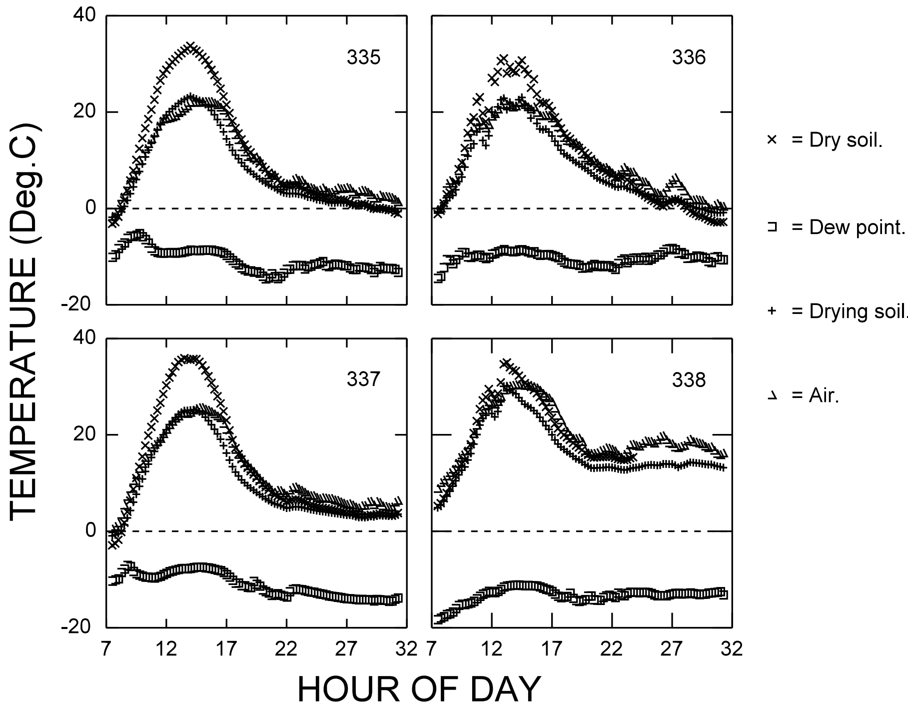

Figure 3-24. Dew point, soil and air temperatures for days 335 through 338, Run 2, Experiment 3.

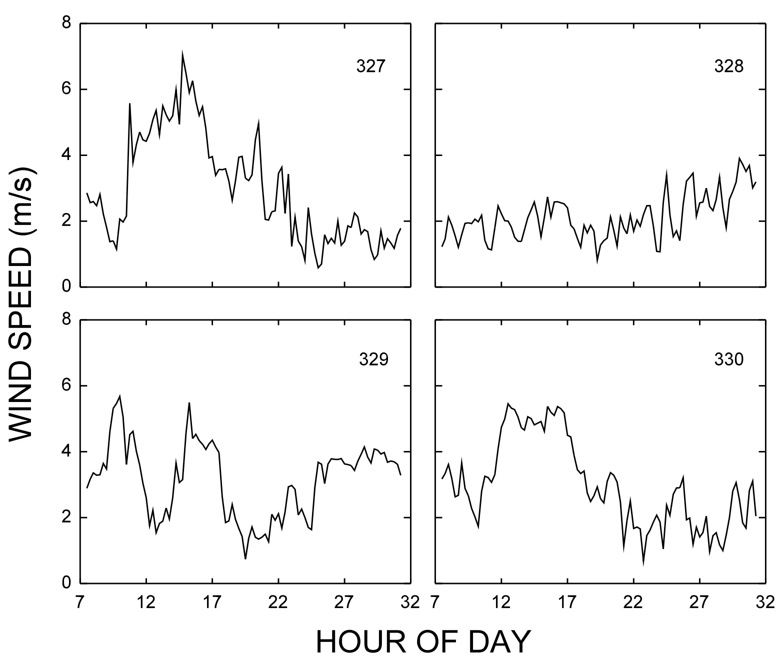

Figure 3-25. Wind speeds averaged over 15 minutes for days 327 through 330. Periods are 24 hours starting at 7:30 AM.

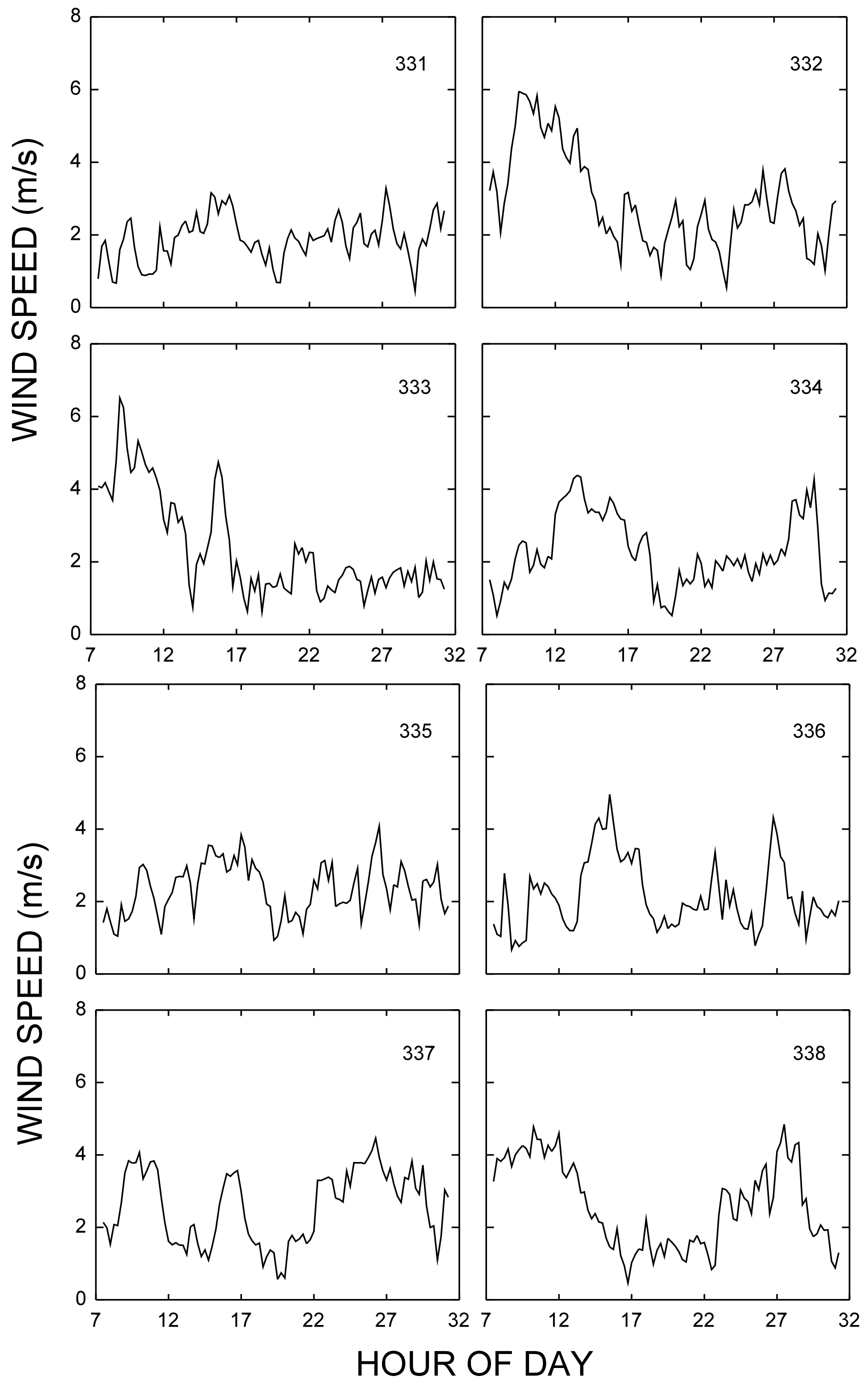

Figure 3-26. Wind speeds averaged over 15 minutes for days 331 through 338. 24 hour periods starting at 7:30 AM.

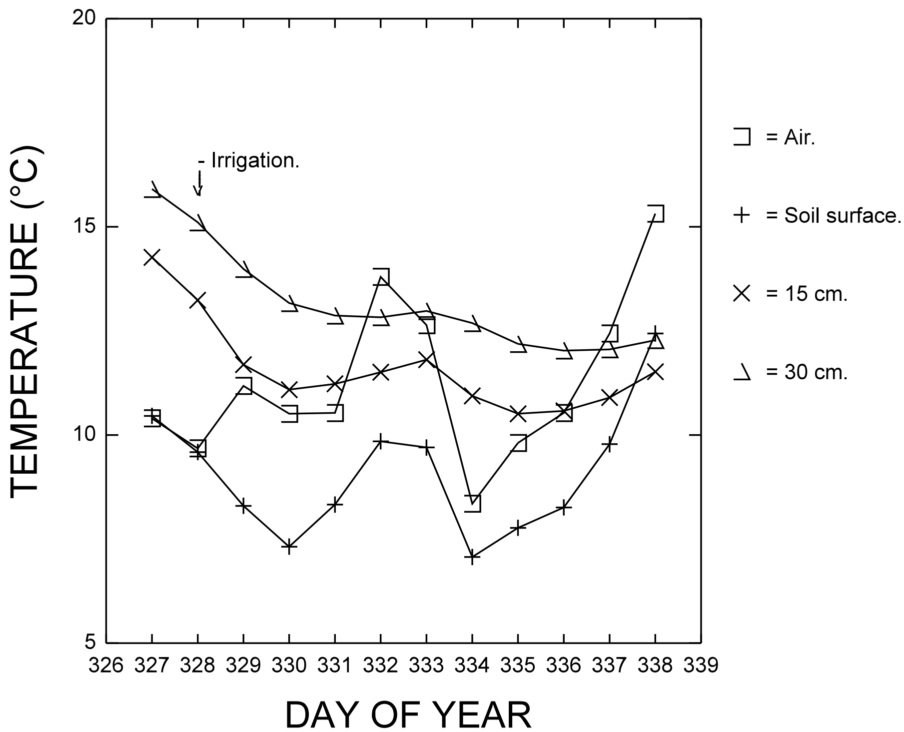

Figure 3-27. Average daily soil and air temperatures measured by thermistor before and during the Run 2, Experiment 3 (Average of 96 measurements taken at 15 minute intervals).

air masses passed over the experimental site (Figure 3-27).

The maximum evaporation measured by ML was, at 8.2 mm on the first day after irrigation, just under the potential ET of 8.8 mm for that day (Table 3-17). Potential ET was calculated as shown in Appendix A. The average evaporation was 5.8 mm on the first day decreasing to about one mm a day on the last two days. Measured evaporation generally followed the same trends as potential ET, increasing on especially windy days and decreasing when winds were light and temperatures cool, but superimposed on this behavior was the general reduction in evaporation associated with soil drying.

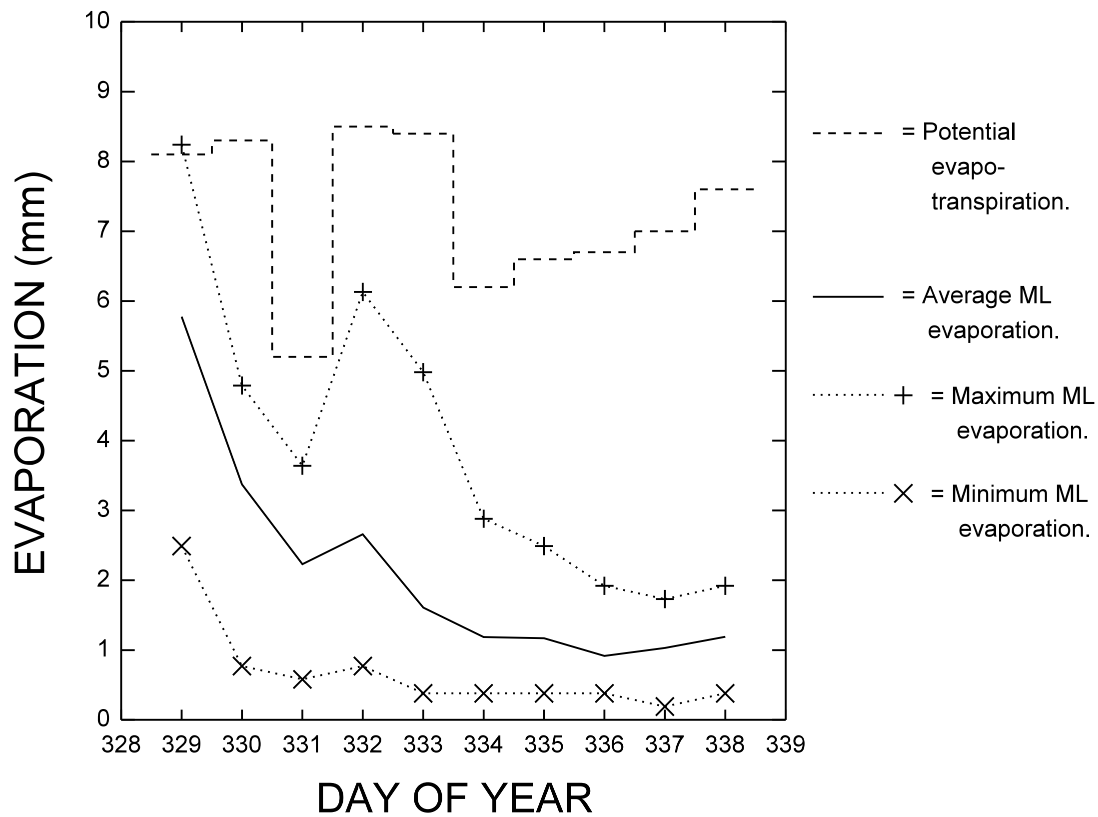

Figure 3-28. Average, maximum and minimum measured evaporation compared to potential evapotranspiration, Run 2, Experiment 3.

Initial and final ML water contents averaged 0.318 and 0.253 m^3/m^3, respectively, giving a change of 0.065 m^3/m^3 or an average of 19.7 mm of water lost over the run (Table 3-16). This was 82% of the 24 mm of water applied but just 20% of the 96 mm of water in the ML's just after irrigation. By contrast the final water content of the field, as measured by 20 volumetric samples to 30 cm depth, was 0.206 m^3/m^3. Assuming that initial water contents of ML's and field soil were equal, this amounted to a 0.112 m^3/m^3 change in storage, equivalent to 33.9 mm of water lost from a 30.3 cm deep profile. Subtracting 19.7 mm of evaporation from the 33.9 mm change in storage leaves 14.2 mm of water lost to drainage.

Table 3-16.

Water balance for Run 2, Experiment 3.

	Depth (mm)	Water Content (m^3/m^3)	
Irrigation	24.0	----	
Microlysimeters			
Initial	96.4	0.318	
Final	76.7	0.253	
Change	19.7	0.065	<- evaporation.
Field			
Initial (ML)	96.4	0.318	
Final	62.4	0.206	
Change	33.9	0.112	<- evaporation + drainage.
ML final minus Field final	14.2	0.047	<- Drainage.

Table 3-17.

Run 2, Experiment 3 daily values. Measured (Evap.) and potential (ET_p) evaporation, average morning and midday IR temperatures of ML's (Min T_d, Max T_d) and reference dry soil (Min T_o, Max T_o), 24 hour and daytime average wind, precipitation, and average air temperature (7:30 AM to 7:30 AM averages). Wind speed corrected to 2 m height (see Appendix A).

Julian day	Max. Evap.	Min. Evap.	Ave. Evap.	Min. T_d	Max. T_d	Min. T_o	Max. T_o	Ave. Wind	Daytime Wind	ET_p	Precip.	Air Temp
	(mm)			(°C)		(°C)		(m/s)		(mm)	(mm)	°C
329	8.2	2.5	5.8	0.24	18.52	0.24	33.50	2.70	3.31	8.1	0	11.18
330	4.8	0.8	3.4	1.09	17.38	1.54	30.10	3.21	3.75	8.3	0	10.51
331	3.6	0.6	2.2	0.55	21.76	0.44	34.20	1.74	1.78	5.2	0	10.53
332	6.1	0.8	2.7	0.67	20.96	0.31	32.17	2.56	3.49	8.5	0	13.80
333	5.0	0.4	1.6	1.17	21.55	0.85	29.08	2.49	3.19	8.4	0	12.64
334	2.9	0.4	1.2	-0.27	22.06	-1.34	30.64	1.90	2.45	6.2	0	8.35
335	2.5	0.4	1.2	-2.09	24.84	-3.18	33.75	2.14	2.23	6.6	0	9.81
336	1.9	0.4	0.9	-0.41	21.97	-1.15	31.13	2.12	2.26	6.7	0	10.53
337	1.7	0.2	1.0	-0.37	28.47	-2.91	35.92	2.03	2.30	7.0	0	12.44
338	1.9	0.4	1.2	3.29	22.26	3.16	26.26	2.54	2.85	7.6	0	15.32